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JOURNAL of PALEONTOLOGY

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LOWER OLIGOCENE FORAMINIFERA FROM MEXICO

W. L. F. NUTTALL
Tampico, Mexico

ABSTRACT

One hundred and thirty-five species and varieties of smaller foraminifera are identified from the Lower Oligocene Alazan shale of the Tampico Embayment, Mexico. Twenty-three new species and five new varieties are described.

INTRODUCTION

Beds of Lower Oligocene age in the Tertiary Tampico Embayment of Mexico have been named Alazan shale. This term was originally used by Dumble,[1] who considered the strata to be Upper Eocene. Vaughan[2] and Cooke[3] have shown that the Alazan is Lower Oligocene (Vicksburg), the latter basing his conclusions on the study of the molluscan fauna collected from the type locality. The Alazan is overlain by the Middle Oligocene Meson and underlain by the Upper Eocene Chapapote (Jackson).

Cushman[4] has published a series of papers on the smaller foraminifera of the Tampico Embayment, beds of both Lower Oligocene and Upper Eocene age being classified under the term Alazan. Cushman's "Alazan species" therefore contain forms from the Lower Oligocene as well as from the Upper Eocene. The latter fauna has formed the subject of a paper by Cole,[5] the formation being distinguished under the name Chapapote. In the following paper, 135 species and varieties of smaller foraminifera are identified and it is shown that an upper and lower division of the Alazan may be distinguished.

This paper is published by permission of the Mexican Eagle Oil Company. Its publication would have been impossible if it were not for the generous coöperation of Dr. J. A. Cushman, to whom the writer expresses his indebtedness. He outlined the drawings, which were prepared in his laboratory, gave valuable advice regarding

[1] Dumble, E. T., 1918, *Proc. Cal. Acad. Sci.*, ser. 4, vol. 8, pp. 141-142.

[2] Vaughan, T. W., 1924, *Bull. Geol. Soc. Am.*, vol. 35, p. 731.

[3] Cooke, C. W., 1928, *Proc. U. S. Nat. Mus.*, vol. 73, art. 10, pp. 1-11, pls. 1, 2.

[4] Cushman, J. A., 1924, *Proc. U. S. Nat. Mus.* vol. 66, art. 30, pp. 1-4, pls. 1, 2;—1925, *Contr. Cushman Lab. Foram. Res.*, vol. 1, pp. 4-8, pl. 1, pp. 61-62, pl. 10;—1926, *idem.*, pp. 81-84, pl. 12, p. 88, pl. 13;—1927, *idem.*, vol. 3, pp. 111-116, pls. 22, 23;—1926, *Proc. U. S. Nat. Mus.*, vol. 67, art. 25, pp. 1-24, pls. 1-6;—1927, *idem.*, vol. 70, art. 16, pp. 1-8, pls. 1, 2;—1927, *idem.*, vol. 72, art. 20, p. 6, pl. 4;—1927, *Jour. Pal.*, vol. 1, pp. 147-172, pls. 23-28.

[5] Cole, W. S., 1928, *Bull. Am. Pal.*, vol. 14, no. 53, pp. 3-21, pls. 1-3.

the identification of certain forms, and sent slides of species for comparison. The illustrations are partly drawings by Miss Margaret Moore and microphotographs by the author. Mrs. H. J. Plummer kindly supplied material from the coastal plains Oligocene of the United States. The slides of all the species mentioned in this paper, including the figured specimens, have been deposited in Dr. Cushman's collections.

STRATIGRAPHIC DISTRIBUTION OF THE SPECIES

With the aid of the foraminifera, a lower division of the Alazan may be readily distinguished from an upper. The chief feature is that the former is characterized by the presence of numerous species absent in the latter. The commoner of these forms are:

Characteristic Foraminifera of the Lower Alazan Shale

Anomalina grosserugosa
Cibicides cushmani
Cibicides mexicana
Cibicides perlucida
Cibicides tuxpamensis
Cristellaria subpapillosa
Gaudryina bradyi
Gyroidina girardana
Nodosarella salmojraghii
Nodosarella subnodosa
Nodosaria spinicosta
Planulina wuellerstorfi
Pulvinulinella (?) culter var. mexicana
Vaginulina elegans var. mexicana
Vulvulina capreolus var. spinosa

Certain species present in the Chapapote have not been observed to range up into the Alazan. Nine of these have been mentioned elsewhere by the writer.[6] A disconformity has frequently been observed at the base of the Oligocene and derived Eocene foraminifera are sometimes found in the basal fifty feet or so of the Oligocene. These last conditions are found in parts of the Buenavista river valley and notably at and near the Alazan type locality.

Lower Oligocene species of interest from the point of view of their geographic and stratigraphic distribution elsewhere include:

Occurrence Elsewhere of Certain Alazan Foraminifera

Bifarina vicksburgensis, Vicksburg of Mississippi
Bolivina caelata, Vicksburg of Mississippi, Alabama and Florida; Oligocene of Trinidad and Venezuela
Bolivina tongi, Tertiary, Venezuela
Bulimina sculptilis, Vicksburg of Mississippi, Alabama, Florida; Lower Oligocene of Oregon
Cibicides trinitatensis, Oligocene of Trinidad
Eponides byramensis, Vicksburg of Mississippi, Alabama and Florida
Rotalia vicksburgensis, Vicksburg of Mississippi, Alabama and Florida

THE LOCALITIES OF THE SAMPLES

This study of the Mexican Lower Oligocene foraminifera is based on a detailed study of samples from about 200 selected natural surface outcrops from stratigraphic horizons ranging from the base of the Meson to the top of the Chapapote, all from the State of Veracruz.

The upper part of the Alazan was represented by material from western Asuncion. This land is bounded to the southwest by Tumbadero Hacienda, to the north by Temapache and to the south by the Tuxpam River. The samples were collected in a strip about 4

[6] Nuttall, W. L. F., 1930, *Jour. Pal.*, vol. 4, p. 272.

kilometers wide parallel to the southwestern boundary of Asuncion.

Samples from the lower part of the Alazan were collected from two distinct areas. The first is from the Haciendas of Palma Real and Llano Grande, which are situated southeast of Potrero del Llano and bounded to the west by the Rio Buenavista. Samples from this area are from the vicinity of San Miguel village, which is situated just south of the boundary of Palma Real and Llano Grande. Others are from near La Ceiba crossing, which is located where the southern Llano Grande boundary with Tumbadero joins the Rio Buenavista.

The second area from which samples of Lower Alazan have been studied is from the vicinity of Mecatepec, south of the Tuxpam River, the material being from north of the basalt Mesa in the vicinity of wells 4 and 5. The above samples were collected by Messrs. C. W. Creek, W. R. Fehr, T. F. Grimsdale, H. Hemmings, H. Jenny and H. Meyer, geologists of the Eagle Oil Company.

The localities of the figured specimens are as follows:

(1) Western Asuncion: pl. 1, figs, 1, 4, 5, 7-11, 13-16; pl. 2, figs. 3, 5, 7-11; pl. 3, figs. 1-3, 5, 7-11, 13-15; pl. 4, fig. 1; pl. 5, figs. 1-7, 9-11; pl. 6, figs. 1-15; pl. 7, figs. 7, 10, 11; pl. 8, figs. 1-9.

(2) 1¼ km. northwest of La Ceiba crossing of the Rio Buenavista, Hacienda Llano Grande: pl. 1, figs. 6, 12; pl. 2, figs. 4, 6; pl. 4, figs. 3, 5, 6; pl. 7, figs. 2, 3, 9.

(3) 2 km. S. 55° W. of La Ceiba crossing of the Rio Buenavista, Hacienda Llano Grande: pl. 3, figs. 12, 16; pl. 4, figs. 4, 7.

(4) San Miguel, Hacienda Palma Real: pl. 4, figs. 2, 10, 13-15; pl. 5, figs. 12, 13; pl. 9, figs. 7-9.

(5) 1 km. northwest of San Miguel, Hacienda Palma Real: pl. 3, figs. 4, 6; pl. 4, fig. 17; pl. 8, figs. 10-12.

(6) 3½ km. southeast of Potrero del Llano: pl. 7, fig. 1.

(7) 3¼ km. west of Coazintla: pl. 1, fig. 3.

(8) Hacienda of Mecatepec: pl. 1, fig. 2; pl. 2, figs. 1, 2; pl. 4, figs. 8, 9, 11, 12, 16; pl. 5, fig. 8; pl. 7, figs. 4-6, 8; pl. 9, figs. 1-6, 10.

DESCRIPTION OF SPECIES

Family AMMODISCIDAE

Genus AMMODISCUS Reuss

AMMODISCUS INCERTUS (d'Orbigny)

Operculina incerta D'ORBIGNY, *1839*, in de La Sagra, Hist. Phys. Pol. Nat. Cuba "Foraminifères," p. 49, pl. 6, figs. 16, 17.

Ammodiscus incertus (d'Orbigny) BRADY, *1884*, Rep. *Challenger*, p. 330, pl. 38, figs. 1-3.

Ammodiscus tenuis BRADY, *1884*, Rep. *Challenger*, p. 332, pl. 38, figs. 4-6.

The specimens show variation in the width of the whorls and the texture of the test, which is generally finely arenaceous.

Family TEXTULARIIDAE

Genus TEXTULARIA Defrance

TEXTULARIA MISSISSIPPIENSIS Cushman var. ALAZANENSIS Nuttall, n. var.

Plate 1, figure 1

Var. of *Textularia mississippiensis* CUSHMAN, *1922*, U. S. Geol. Survey, Prof. Paper 129, p. 90, pl. 14, fig. 4.

This variety differs from the typical species in the lesser degree of limbation of the sutures and, in particular, the presence of a narrower central ridge. The periphery also differs in having a narrow flange, extended into irregular angled projections, which are frequently broken off. The texture is finely arenaceous and the chamber

surfaces flattened, which last feature distinguishes it from *T. carinata* d'Orbigny. This species has been compared with *T. mississippiensis* from the Red Bluff clay of Mississippi and the above distinguishing features were found to be constant.

TEXTULARIA DENTIMARGINATA, Nuttall, n. sp.
Plate 1, figure 2

Test compressed, widest across the apertural end. Sutures narrow, depressed, about seven chambers; central line of junction of the chambers elevated. Periphery acute, in parts somewhat spinose due to backward projections of the chambers. Apertural face flattened. Length 0.6 mm.

This form differs from *T. mexicana* Cushman[7] in being more flattened and in having fewer chambers.

Genus VULVULINA d'Orbigny

VULVULINA CAPREOLUS var. SPINOSA (Cushman)

Vulvulina spinosa CUSHMAN, *1927,* Contr. Cushman Lab. Foram. Research, vol. 3, p. 111, pl. 23, fig. 1.—*1927,* Jour. Pal., vol. 1, p. 149, pl. 28, fig. 4.

[7] Cushman, 1922, *U. S. Nat. Mus., Bull.* 104, pt. 3, p. 17, pl. 2, fig. 9.

The degree to which the angular projections are developed is a variable factor, specimens being found which closely approach *V. capreolus* d'Orbigny as figured by Brady.[8] In addition to the form showing the uniserial final chambers, shorter stout biserial specimens occur.

Family VERNEUILINIDAE

Genus VERNEUILINA d'Orbigny

VERNEUILINA MEXICANA Nuttall, n. sp.
Plate 2, figures 1, 2

Test fusiform, short stout. Initial end subconical, subacute; apertural end rounded; test broadest across the middle of the last three chambers. Triserial throughout, sutures depressed, indistinct. Aperture at the base of the last chamber consisting of an elongate slit, variable in length. Wall fairly coarsely arenaceous. Average length 0.9 mm.

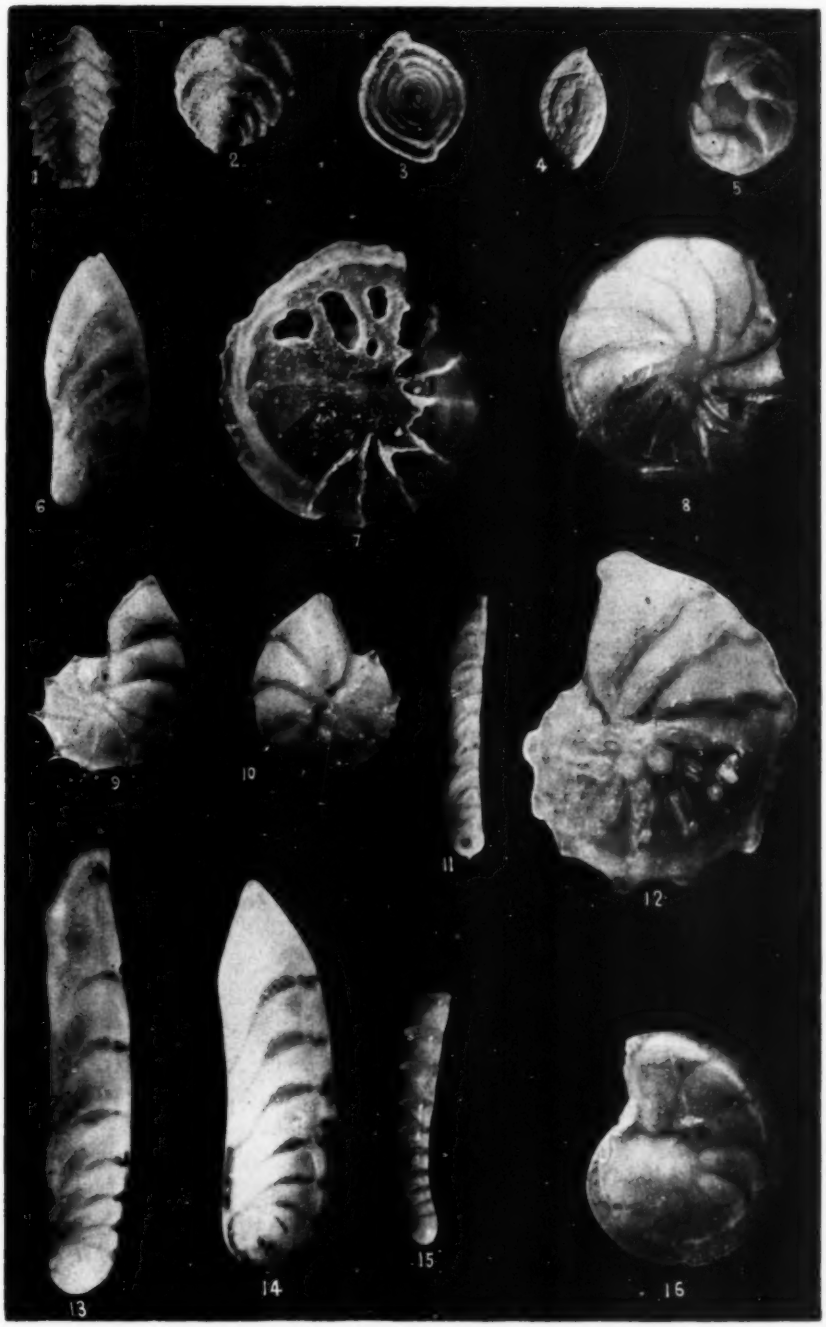
This species resembles *V. cyclostomata* Galloway and Morrey,[9] the

[8] Brady, 1884, *Rep.* Challenger, pl. 45, figs. 1-4.

[9] Galloway and Morrey, 1929, *Bull. Am. Pal.,* vol. 15, no. 55, p. 33, pl. 5, fig. 2.

EXPLANATION OF PLATE 1

FIGS. 1—*Textularia mississippiensis* Cushman var. *alazanensis* Nuttall, n. var., × 30.
2—*Textularia dentimarginata* Nuttall, n. sp., × 30.
3—*Spiroloculina* aff. *depressa* d'Orbigny, × 30.
4—*Sigmoilina tenuis* (Czjzek), × 25.
5—*Cristellaria budensis* Hantken, × 30.
6—*Cristellaria crepidula* (Fichtel and Moll), × 30.
7—*Cristellaria cultrata* d'Orbigny var., × 15.
8—*Cristellaria kemperi* Hanna, × 30.
9—*Cristellaria calcar* (Linné) var. *alazanensis* Nuttall, n. var., × 25.
10—*Cristellaria formosa* Cushman, × 25.
11, 15—*Vaginulina alazanensis* Nuttall, n. sp., × 30.
12—*Cristellaria subpapillosa* Nuttall, n. sp., × 25.
13, 14—*Cristellaria sublituus* Nuttall, n. sp., fig. 13 × 60, fig. 14 × 70.
16—*Cristellaria subkubinyii* Nuttall, n. sp., × 20.



Nuttall—Oligocene Foraminifera from Mexico

aperture of this form being however quite distinct with a raised rim. Cushman[10] considers this last species to be a young *Clavulina.*

Genus GAUDRYINA d'Orbigny

GAUDRYINA BRADYI Cushman

Gaudryina bradyi CUSHMAN, *1911,* U. S. Nat. Mus., Bull. 71, pt. 2, p. 67, fig. 107.—NUTTALL, *1930,* Jour. Pal., vol. 4, p. 281.

In Mexico this species ranges down to the Aragon.

GAUDRYINA JACKSONENSIS Cushman

Plate 2, figure 5

Gaudryina jacksonensis CUSHMAN, *1926,* Contr. Cushman Lab. Foram. Research, vol. 2, p. 33, pl. 5, figs. 1a, b.

This large triangular *Gaudryina* is a fairly common form characteristic of the Alazan.

GAUDRYINA ASIPHONIA (Andrae)

Plate 2, figure 3

Gaudryina siphonella var. *asiphonia* ANDREAE, *1884,* Abh. Geol. Specialkarte Elsass-Lothr., vol. 2, p. 200, pl. 7, fig. 7.—KLÄHN, *1917,* Mitteilungen Nat. Ges. Colmar, N. F., vol. 14, p. 10, pl. 7, figs. 1, 3, 5, 7, 8, 11; pl. 8, fig. 1.

Test elongate, tapered, triserial portion consisting of about one-quarter its length. Sutures narrow, distinct, the chambers becoming increasingly larger, the last four or six chambers more inflated than those preceding. Surface fairly finely arenaceous. Aperture an arched opening at the base of the last chamber. Length 0.6 mm. The Alazan species appears to be the same as this form described from the Oligocene of Alsace.

[10] Cushman, 1929, *Contr. Cushman Lab. Foram. Research,* vol. 5, p. 80, pl. 12, figs. 8, 9.

GAUDRYINA CYLINDRICA Nuttall, n. sp.

Plate 2, figure 7

Test elongate, cylindrical with rounded initial end and width of test increasing only very slightly towards the peripheral end. Triserial portion occupying about one-third of the length of the test. Sutures narrow, generally very slightly depressed, frequently indistinct. Aperture short, elongate oval, situated near the base of the last chamber and running parallel to the line of junction of the last chamber with the preceding one. Length 1.3 mm., width 0.4 mm.

This species appears to resemble closest *G. subrotundata* Schwager,[11] which is however compressed and has a different aperture. *G. praelonga* Karrer[12] may be distinguished by its more wedge-shaped form and more depressed sutures.

GAUDRYINA COLEI Nuttall, nom. nov.

Plate 2, figure 6

Gaudryina reussi HANTKEN, *1868,* Magyar Földt. Társulat. Munkálatai, vol. 4, p. 83, pl. 1, fig. 2;—*1875* (1876) Magyar. kir. földt. int. évkön., vol. 4, p. 11, pl. 1, fig. 5 (not Stache 1864).

Gaudryina hantkeni NUTTALL, *1928,* Quart. Jour. Geol. Soc., vol. 84, p. 75, pl. 3, figs. 13, 14 (not Lörenthey, 1909).

This form was recorded by the writer from Trinidad and the same species occurs sparingly here. The above new name has been proposed since *G. hantkeni* has been used by Lörenthey; it is named in honor of Mr. W. S. Cole, who has described numerous foraminifera from Mexico.

[11] Schwager, 1866, *Novara Exped., Geol.* (2), p. 198, pl. 4, fig. 9.

[12] Karrer, 1877, *Abh. K. K. Geol. Reichanst.,* vol. 9, p. 374, pl. 16a, fig. 6.

Genus CLAVULINA d'Orbigny

CLAVULINA TRIANGULARIS Nuttall, n. sp.
Plate 2, figure 4

Test tricarinate, sides flattened or slightly concave, periphery subacute. Shape generally with the sides parallel for the greater part of the length of the test and somewhat tapered towards the initial end. Triserial part short, with the chambers not visible externally. Uniserial portion occupying the greater length of the test, sutures indistinct, depressed. Initial end blunt. Aperture terminal, central, circular and small. Texture fairly coarsely arenaceous.

This form resembles *Clavulina szaboi* Hantken and in particular var. *kruhelensis* Wojcik,[13] which differs by having a longer triserial portion, a more acute initial end and a tubular aperture.

CLAVULINA ALAZANENSIS Nuttall, n. sp.
Plate 2, figure 10

Test elongate, tapered. Triserial portion occupying from about one-third to one-half the length of the test. Initial end subacute. Uniserial part of the test with three or four globose chambers with constricted necks. Aperture with an extended circular neck. Texture fairly coarsely arenaceous. Average length 0.8 mm.

Dr. Cushman has kindly compared this form with the types of *C. humilis* var. *mexicana*,[14] which it resembles. He informs me that the Alazan species is more slender and the chambers more clearly separated. Also var. *mexicana* had a much shorter triserial portion, which is more flaring.

Family MILIOLIDAE

Genus SPIROLOCULINA d'Orbigny

SPIROLOCULINA aff. DEPRESSA d'Orbigny
Plate 1, figure 3

Spiroloculina depressa D'ORBIGNY, *1826*, Ann. Sci. Nat., vol. 7, p. 298. Modèle No. 92.

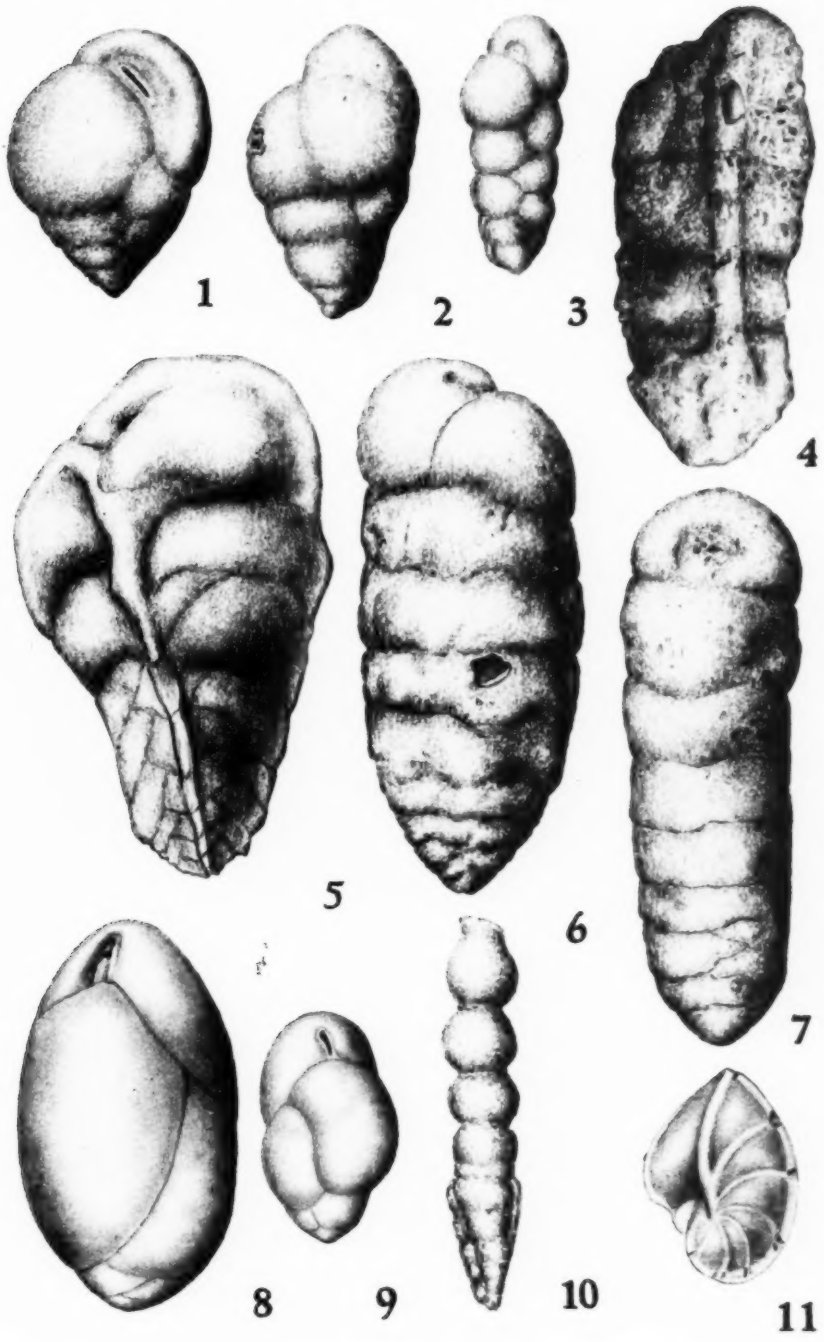
The specimens show the borders of the chambers elevated into narrow ridges. Owing to the confusion that exists in the literature regarding this species it is at present impossible to be certain regarding its identification.

[13] Wojcik, 1903, *Abh. d. math.-nat. Kl. d. Krakauer Akad. Wiss.*, vol. 48, pl. 17, fig. 21.

[14] Cushman, 1922, *U. S. Nat. Mus.*, Bull. 104, pt. 3, p. 83, pl. 16, figs. 1-3.

EXPLANATION OF PLATE 2

FIGS. 1, 2—*Verneuilina mexicana* Nuttall, n. sp., × 60.
3—*Gaudryina asiphonia* (Andreae), × 60.
4—*Clavulina triangularis* Nuttall, n. sp., × 50.
5—*Gaudryina jacksonensis* Cushman, × 60.
6—*Gaudryina colei* Nuttall, nom. nov., × 40.
7—*Gaudryina cylindrica* Nuttall, n. sp., × 60.
8—*Bulimina ovata* d'Orbigny, × 60.
9—*Bulimina pupoides* d'Orbigny, × 60.
10—*Clavulina alazanensis* Nuttall, n. sp., × 60.
11—*Cristellaria* aff. *latifrons* Brady, × 50.



Nuttall—Oligocene Foraminifera from Mexico

Genus SIGMOILINA Schlumberger

SIGMOILINA TENUIS (Czjzek)
Plate 1, figure 4

Quinqueloculina tenuis CZJZEK, *1848,* Haidinger's Nat. Abh., vol. 2, p. 149, pl. 13, figs. 31-34.
Sigmoilina tenuis (Czjzek) CUSHMAN, *1929,* Contr. Cushman Lab. Foram. Research, vol. 5, p. 81, pl. 12, figs. 12-14.

The specimens examined are compressed with the chambers not clearly visible. The aperture is exserted and circular, while the test is white and chalky in texture. This species has a wide range from late Tertiary to Recent.

Family LAGENIDAE

Genus CRISTELLARIA Lamarck

CRISTELLARIA BUDENSIS (Hantken)
Plate 1, figure 5

Robulina budensis HANTKEN, *1875* (1876), Magyar kir. földt. int. évkön., vol. 4, p. 49, pl. 7, fig. 1.

The forms referred to this species have somewhat inflated chambers, a narrow thin peripheral flange and an oval aperture. It is frequent in the Alazan.

CRISTELLARIA CONVERGENS Bornemann

Cristellaria convergens BORNEMANN, *1855,* Zeitschr. Deutsch. Geol. Ges., vol. 7, p. 327, pl. 13, figs. 16, 17.—NUTTALL, *1930,* Jour. Pal., vol. 4, p. 282 and references.

This species ranges down into the Aragon.

CRISTELLARIA CREPIDULA (Fichtel and Moll)
Plate 1, figure 6

Nautilus crepidula FICHTEL and MOLL, *1803,* Test. Micr., p. 107, pl. 19, figs. g-i.
Cristellaria crepidula (Fichtel and Moll) D'ORBIGNY, *1839,* in de la Sagra, Hist. Phis. Pol. Nat. Cuba "Foraminifères," p. 41, pl. 8, figs. 17, 18.—BRADY, *1884,* Rep. *Challenger,* p. 542, pl. 67, figs. 17, 19, 20; pl. 68, figs. 1, 2.

The specimens have a rounded border and stellate aperture.

CRISTELLARIA CALCAR (Linné) var. ALAZANENSIS Nuttall, n. var.
Plate 1, figure 9

Test compressed, earlier part close-coiled, adult specimens with a few uncoiled chambers. Sutures depressed, gently curved, border rounded with no keel. A short stout backwardly directed spine is situated at the point where each suture reaches the periphery. Aperture oval, near the border. This variety is rather uncommon, it differs from the typical chiefly in having uncoiled chambers. Length up to 1 mm.

CRISTELLARIA CULTRATA (Montfort)

Robulus cultratus Montfort, CUSHMAN, *1927,* Jour. Pal., vol. 1, p. 151, pl. 23, fig. 7.

Cushman has figured a common form of this species from the Alazan, which has from six to seven chambers and a fairly wide peripheral keel.

CRISTELLARIA CULTRATA (Montfort) var.
Plate 1, figure 7

A large varietal form of this species is frequent in the Alazan; it attains a diameter of 2.7 mm. The center is devoid of an umbo, the sutures are thick, not raised and gently curved; there are about 14 chambers in the last whorl. The periphery has a wide thick flange of clear shell substance and the aperture is radiate.

CRISTELLARIA FORMOSA Cushman
Plate 1, figure 10

Cristellaria formosa CUSHMAN, *1923,* U. S. Nat. Mus., Bull. 104, pt. 4, p. 110, pl. 29, fig. 1; pl. 30, fig. 6.—NUTTALL, *1928,*

Quart. Jour. Geol. Soc., vol. 84, p. 86, pl. 5, fig. 5.
Robulus formosus (Cushman) CUSHMAN, *1930,* Jour. Pal., vol. 4, p. 358, pl. 32, fig. 10.

The forms which are referred to this species have raised limbate sutures with short spines at the periphery; the aperture is radiate. The sutures are more raised than in the living form, but in this respect appear like the specimen figured by Cushman from the Miocene of Jamaica.

CRISTELLARIA GUTTICOSTATA (Gümbel)

Robulina gutticostata GÜMBEL, *1868,* Abh. m.-ph. Cl. K. Bayer. Ak. Wiss., vol. 10, p. 643, pl. 1, fig. 74.—HANTKEN, *1875,* Magy. kir. földt. int. évkön., vol. 4, p. 48, pl. 6, fig. 10.

Forms assigned to this species have a thin flanged keel, which is not always present, a stellate aperture and beads on the sutures. The chamber surface between the sutures is generally smooth, but in some specimens small granules are present, particularly on the first few chambers of the last whorl. A specimen of this species from Mexico was figured by Cushman,[15] by printer's error referred to *R. mexicanus* in the explanation of plates.

CRISTELLARIA HELENA Karrer

Cristellaria helena KARRER, *1877,* Abh. K. K. Geol. Reichanst., vol. 9, p. 384, pl. 16 b, fig. 42.—NUTTALL, *1928,* Quart. Jour. Geol. Soc., vol. 84, p. 87, pl. 5, fig. 15.
Robulus budensis CUSHMAN (not Hantken), *1927,* Jour. Pal., vol. 1, p. 151, pl. 23, fig. 11.

This form differs from *C. budensis* in being larger, having a wider peripheral flange, in the chambers being more inflated, and in the umbonal region having one or more bosses which are variable in degree of development as well as numbers. The aperture is an elongate slit. This species is much less common than *C. budensis.*

CRISTELLARIA INORNATA (d'Orbigny)

Robulina inornata D'ORBIGNY, *1846,* Foram. Foss. Vienne, p. 102, pl. 4, figs. 25, 26.—CUSHMAN and BARKSDALE, *1930,* Contr. Dept. Geol., Stanford Univ., vol. 1, no. 2, p. 62, pl. 11, figs. 2, 3.

The forms assigned to this species have a fairly large central boss, which is not sharply defined. There are seven to eight chambers with gently curved narrow sutures. The apertures of the majority of specimens is broken so as to show an elongate slit.

CRISTELLARIA KEMPERI Hanna

Plate 1, figure 8

Cristellaria kemperi HANNA, *1923,* Univ. Cal. Publ. Geol. Sci., vol. 14, p. 323, pl. 59, fig. 1.
Robulus midwayensis COLE AND GILLISPIE (not Plummer), *1930,* Bull. Am. Pal., vol. 15, no. 57 b, p. 6, pl. 2, fig. 12.

In this form, the central umbo is not raised and is small, also the limbate sutures are of approximately the same width near the center as towards the periphery. These characters distinguish it from *C. midwayensis,* which has a prominent umbo and raised sutures that become narrower from near the center towards the periphery and are also generally more raised. The specimens found in the Alazan are identical with that from the Meson of Mexico figured by Cole. In some varieties a narrow peripheral flange is developed.

[15] Cushman, J. A., *Jour. Pal.,* 1927, vol. 1, p. 171, pl. 23, fig. 8.

C. kemperi was originally described from the Eocene of California and is a convenient name for certain limbate forms of the *rotulata* group.

CRISTELLARIA ITALICA (Defrance)

Saracenaria italica DEFRANCE, *1824,* Dict. Sci. Nat., vol. 32, p. 177; vol. 47, 1827, p. 344; Atlas Conch., pl. 13, fig. 6.—CUSHMAN, *1929,* Contr. Cushman Lab. Foram. Research, vol. 5, p. 88, pl. 13, fig. 14.

The form present is the same as that found in the Tertiary of Trinidad and Venezuela, being short, with few chambers.

CRISTELLARIA aff. LATIFRONS Brady
Plate 2, figure 11

Cristellaria latifrons BRADY, *1884,* Rep. *Challenger,* p. 544, pl. 68, fig. 19; pl. 113, fig. 11.

Test short with few chambers. Surface of last chamber broad and large, extending down to near the last chambers of the uncoiled portion. Periphery with a thin keel of variable width. Aperture stellate. Length 0.6 mm.

The form from the Alazan differs from the above species in the shape of the apertural face of the last chamber. According to Brady, in the living specimens it is elongate oval, while in the Mexican forms it is proportionately shorter and wider across the central portion. The above species has been recorded as living in the West Indies, Gulf of Mexico, and elsewhere, Brady's figures being of specimens from off New Zealand.

CRISTELLARIA LIMBOSA (Reuss)

Robulina limbosa REUSS, *1864,* Sitz. K. Ak. Wiss. Wien, vol. 48, pt. 1, p. 55, pl. 6, fig. 69.—SCHLICHT, *1870,* Foram. Pietzpuhl, pl. 19, figs. 13, 14.—HANTKEN, *1875* (1876), Magyar. kir. földt. évkön., vol. 4, p. 48, pl. 6, fig. 11.

This name is here applied to a multiseptate close-coiled *Cristellaria* with a central boss and a fairly narrow peripheral flange. There are about eleven chambers in the last whorl with distinct, gently curved, narrow septa. The aperture is stellate with a secondary slit. The above are references to this species in the Oligocene of Europe.

CRISTELLARIA aff. ROTULATA (Lamarck)

Specimens closely related to this species are distinguished by about seven chambers, gently curved septa, a narrow peripheral keel, a small central boss, and a stellate aperture.

CRISTELLARIA SUBKUBINYII Nuttall, n. sp.
Plate 1, figure 16

Test compressed, close-coiled, usually two coils visible with a wide thin keel of clear shell substance. Center with an ill-defined central slightly raised boss. Sutures thick, gently curved, usually slightly depressed, more rarely a little elevated. Chamber surface smooth, glossy, flattened. Aperture radiate. Average diameter 2 mm.

This species resembles *Robulina kubinyii*[16] Hantken, from which it is distinguished by being less close-coiled and having more curved sutures.

CRISTELLARIA SUBLITUUS Nuttall, n. sp.
Plate 1, figures 13, 14

Test much compressed with sharp border, which in parts has a very narrow keel. Surface glossy, smooth,

[16] Hantken, 1875 (1876) *Magyar. kir. földt. évkön.* vol. 4, p. 47, pl. 6, fig. 7.

sutures narrow, oblique, not depressed. Aperture stellate, terminal. Maximum length 1.1 mm., width 0.1 mm.

This species is much more compressed than *Marginulina jacksonensis* (Cushman and Applin),[17] which has been recorded from the Alazan of Mexico. *M. tenuis* Bornemann is also more inflated. A very similar form with which our species can be compared is *M. lituus* Parker and Jones (not d'Orbigny),[18] which is a living species from the North Atlantic. This species differs in having a marked keel in the initial part. *Cristellaria hauerina* var. *gladiiformis* Rzehak[19] differs in being less compressed and in having depressed sutures.

CRISTELLARIA SUBPAPILLOSA Nuttall, n. sp.
Plate 1, figure 12

Test stout, close-coiled with elevated thick limbate sutures bearing large tubercles along their length. Border generally with a narrow flange-like keel of clear shell substance; each suture slightly projecting at the periphery. The number of tubercles on the sutures is variable, and those that are present at the umbilicus are the largest and most prominent. Chamber surface smooth; aperture terminal, radiate. Average diameter 1.0 mm.

This form differs from *C. papillosa* (Fichtel and Moll) in the projections along the border, which are however never as prominent as in *C. echinata* (d'Orbigny) or *C. antillea* Cushman, nor is the border as wide as in *C. mamilligera* Karrer. The species figured by Cushman[20] as *Robulus* cf. *vaughani* (Cushman)? is quite distinct. This last form, which is frequent in the Meson, is smaller and bears more tubercles on the sutures. In the writer's opinion the latter resembles *C. papillosa* nearer than *C. vaughani,* which was described from the Miocene of Panama and in Mexico is restricted to the Tuxpam (Miocene).

Genus MARGINULINA d'Orbigny

MARGINULINA MEXICANA Cushman

Marginulina mexicana CUSHMAN, *1925,* Contr. Cushman Lab. Foram. Research, vol. 1, p. 61, pl. 10, fig. 1.
Marginulina pulchra CUSHMAN, *1925, idem,* p. 61, pl. 10, fig. 2.
Marginulina mexicana Cushman, COLE AND GILLISPIE, *1930,* Bull. Am. Pal., vol. 15, no. 57 b, p. 8, pl. 2, fig. 7.

The above two forms are considered to constitute the microspheric and megalospheric representatives of the same species. *M. mexicana,* the microspheric form, differs in having the earlier portion much more compressed. In *M. pulchra,* the name originally applied to the megalospheric form, the earlier portion of the test is more inflated and a sphaeroidal smooth initial chamber is always present. The two forms are frequently found associated and are common both in the Meson and Alazan.

MARGINULINA SUBBULLATA Hantken

Marginulina subbullata HANTKEN, *1875* (1876), Magyar. kir. földt. int. évkön., vol. 4, p. 39, pl. 4, figs. 9, 10; pl. 5, fig. 9.—CUSHMAN, *1925,* Contr. Cushman Lab. Foram Research, vol. 1, p. 62, pl. 10, figs.

[17] Cushman, J. A., 1927, *Jour. Pal.,* vol. 1, p. 152, pl. 24, fig. 12.
[18] Parker and Jones, 1865, *Phil. Trans. Roy. Soc.,* p. 343, pl. 13, fig. 14.
[19] Rzehak, 1886, *Verh. nat. Ver. Brünn,* vol. 24, p. 101, pl. 1, fig. 9.
[20] Cushman, 1927, *Jour. Pal.,* vol. 1, p. 151, pl. 23, fig. 10.

3 a, b.—COLE, *1927*, Bull. Am. Pal., vol. 14, no. 51, p. 14, pl. 5, fig. 10.—CUSHMAN, *1929*, Contr. Cushman Lab. Foram. Research, vol. 5, p. 85, pl. 12, fig. 20.—CUSHMAN AND LAIMING, *1931*, Jour. Pal., vol. 5, p. 99, pl. 10, fig. 8.

This name has been applied to a small smooth *Marginulina* with inflated chambers and stellate aperture. The inflation of the chambers appears to be the only distinction from *M. glabra* d'Orbigny. This form is distributed in the Alazan and Eocene of Mexico.

MARGINULINA PSEUDOHIRSUTA Nuttall, n. sp.
Plate 3, figures 1, 2

Nodosaria aculeata CUSHMAN (not d'Orbigny), *1927*, Jour. Pal., vol. 1, p. 154, pl. 24, fig. 4.

Both megalospheric and microspheric forms of this species are present, and Cushman has assigned the former to *N. aculeata* d'Orb. His figured specimen did not show the aperture, which consists of a short tubular neck situated near the periphery of the last chamber. This aperture is different from that of d'Orbigny's species, also the ornamentation of the Mexican species is coarser.

The microspheric form differs only in that the initial part is compressed, the termination of the first chamber being pointed and a keel extending along the external margin for about one-third of the length of the test. In both forms the tubercles are coarse and bead-like, while the constrictions between adjacent chambers are smooth. The microspheric form resembles *M. agglutinans* Neugeboren[21] which, however, is more finely hispid and has no keel near the initial part. Average length of both forms 1.5 mm. An analogous couple of forms is found in a similar species, *M. hirsuta* d'Orbigny,[22] the microspheric form of which has much more constricted necks and less compressed initial portion.

MARGINULINA ALAZANENSIS Nuttall, n. sp.
Plate 3, figures 3, 7

Test elongate, cylindrical, surface smooth, glossy. Initial chambers coiled, sutures indistinct; in the earlier part of the uncoiled portion the sutures are oblique and later are at right angles to the longer axis. About six or seven chambers in the linear series. Sutures narrow, depressed, the chambers of the last half of the test becoming more inflated than those of the earlier portion. Aperture terminal, radiate. Length 1.5 mm., width 0.3 mm.

This species is distinguished from *M. regularis* d'Orbigny[23] by having fewer chambers and a radiate aperture. Neugeboren[24] has figured several smooth species of *Marginulina* which differ in having oblique sutures throughout.

MARGINULINA sp.
Plate 3, figure 4

Test compressed, with about twelve narrow longitudinal costae, which are

[21] Neugeboren, 1851, *Verh. Mitth. Siebenburg. Ver. Nat.*, vol. 2, p. 145, pl. 4, fig. 24.

[22] d'Orbigny, 1846, *Foram. Foss. Vienne*, p. 69, pl. 3, figs. 17, 18, Fornasini, 1900, *Mem. Acc. Sci. Ist. Bologna*, ser. 5, vol. 8, pl. 5, fig. 30.

[23] d'Orbigny, 1846, *Foram. Foss. Vienne*, p. 68, pl. 3, figs. 9-12.

[24] Neugeboren, 1851, *Verh. Mitth. Siebenburg. Ver. Nat.*, vol. 2, pls. 4-5.

continuous the whole length of the test. Chambers not inflated, sutures indistinct, last chamber may be rounded and the last half smooth. Aperture terminal, radiate. The initial end generally prolonged to a short spine. Length 1.9 mm., breadth 0.3 mm.

This species belongs to the group of *M. costata* (Batsch) and resembles *M. cocoaensis* Cushman.[25]

Genus DENTALINA d'Orbigny

DENTALINA ADOLPHINA d'Orbigny

Dentalina adolphina D'ORBIGNY, *1846*, Foram. Foss. Vienne, p. 51, pl. 2, figs. 18-20.

The specimens present show a weak development of the spinose projections on the lower part of the chambers.

DENTALINA COCOAENSIS (Cushman)

Nodosaria cocoaensis CUSHMAN, *1925*, Contr. Cushman Lab. Foram. Research, vol. 1, p. 66, pl. 10, figs. 5, 6.
Dentalina cocoaensis (Cushman) CUSHMAN, *1927*, Jour. Pal., vol. 1, p. 153, pl. 24, fig. 14.

This species was figured by Cushman (1927) from the Alazan of Mexico, his illustration being of a microspheric form. The megalospheric form is also present and is distinguished by the inflated character of the first and following chambers and the presence of a short spine or more rarely several spines on the initial end.

[25] Cushman, 1925, *Contr. Cushman Lab. Foram. Research*, vol. 1, p. 67, pl. 10, figs. 9, 10.

DENTALINA COMMUNIS d'Orbigny

Dentalina communis D'ORBIGNY, *1826*, Ann. Sci. Nat., vol. 7, p. 254, no. 35.
Nodosaria communis (d'Orbigny) BRADY, *1884*, Rep. *Challenger*, p. 504, pl. 62, figs. 19-22.—CUSHMAN, *1922*, U. S. Geol. Survey, Prof. Paper 129, p. 129, pl. 30, fig. 4.—NUTTALL, *1928*, Quart. Jour. Geol. Soc., vol. 84, p. 80, pl. 4, fig. 5.

This species is distributed throughout the Oligocene and the Upper and Middle Eocene of Mexico.

DENTALINA MULTILINEATA Bornemann

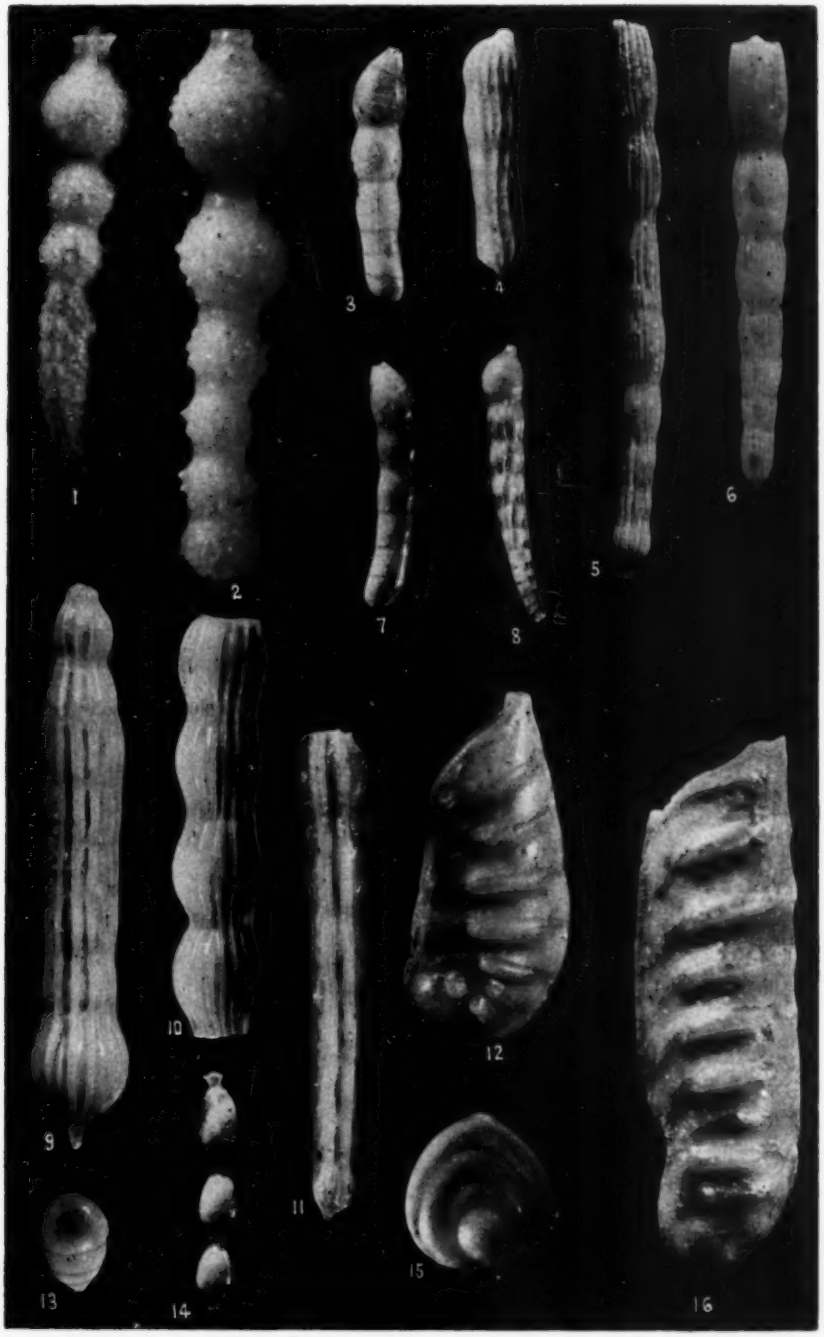
Plate 3, figure 5

Dentalina multilineata BORNEMANN, *1855*, Zeitschr. Deutsch. Geol. Ges., vol. 7, p. 325, pl. 13, fig. 12.—CUSHMAN, *1927*, Jour. Pal., vol. 1, p. 152, pl. 24, figs. 7, 8.

A more complete specimen of this species than that illustrated by Cushman from Mexico is figured in this paper, showing eight chambers, which become more elongate towards the apertural end.

EXPLANATION OF PLATE 3

FIGS. 1, 2—*Marginulina pseudohirsuta* Nuttall, n. sp., × 60.
3, 7—*Marginulina alazanensis* Nuttall, n. sp., × 25.
4—*Marginulina* sp., × 25.
5—*Dentalina multilineata Bornemann*, × 30.
6—*Nodosaria boffalorae* Martinotti, × 20.
8—*Dentalina semilaevis* Hantken, × 30.
9—*Nodosaria vertebralis* (Batsch), × 15.
10—*Nodosaria raphanistrum* (Linné), × 15.
11—*Nodosaria* aff. *carinata* (Neugeboren) × 30.
12, 16—*Vaginulina elegans* d'Orbigny var. *mexicana* Nuttall, n. var., × 30.
13—*Pseudoglandulina ovata* (Cushman and Applin), × 30.
14—*Nodosaria* cf. *soluta* (Reuss), × 25.
15—*Frondicularia alazanensis* Nuttall, n. sp., × 25.



Nuttall—Oligocene Foraminifera from Mexico

DENTALINA SEMILAEVIS Hantken
Plate 3, Figure 8

Dentalina semilaevis HANTKEN, *1875* (1876), Magyar. kir. földt. int. évkön., vol. 4, p. 32, pl. 4, fig. 6; pl. 12, fig. 13.

The specimens from the Alazan have the last or last two chambers smooth, the remainder of the test with low longitudinal costae. The last chamber is extended into a short neck and radiate aperture. The only difference between this and Hantken's figures is the extended neck near the aperture, which is absent in the latter.

Genus NODOSARIA Lamarck

NODOSARIA ACUMINATA Hantken

Nodosaria acuminata HANTKEN, *1875*, (1876), Magyar. kir. földt. int. évkön., vol. 4, p. 23, pl. 2, fig. 9; pl. 13, fig. 5.—CUSHMAN, *1927*, Jour. Pal., vol. 1, p. 155, pl. 24, fig. 9.

Cushman's figure shows a typical specimen from the Alazan of a form which he referred to the above species. As shown in his illustration the Mexican form differs from the specimens figured by Hantken in that the costae are less regular. The initial end is also less tapered, and it would appear that Hantken's specimen (Fig. 9) was microspheric, while the specimens here examined are megalospheric.

NODOSARIA BOFFALORAE Martinotti
Plate 3, figure 6

Nodosaria boffalorae MARTINOTTI, *1923*, Atti. Soc. Ital. Sci. Nat., vol. 62, p. 33, pl. 6, figs. 31-33.—NUTTALL, *1928*, Quart. Jour. Geol. Soc. Lond., vol. 84, p. 82, pl. 4, fig. 16.
Nodosaria sp., COLE, *1928*, Bull. Ann. Pal., vol. 14, no. 53, p. 8, pl. 3, fig. 11.

Broken specimens of this species occur, the aperture apparently being simple tubular. Cole figured a rather coarse ribbed specimen from the Chapapote.

NODOSARIA LONGISCATA d'Orbigny

Nodosaria longiscata D'ORBIGNY, *1846*, Foram. Foss. Vienne, p. 32, pl. 1, figs. 10-12.—CUSHMAN, *1929*, Contr. Cushman Lab. Foram. Research, vol. 5, p. 86, pl. 12, figs. 25, 26.—COLE AND GILLISPIE, *1930*, Bull. Am. Pal., vol. 15, no. 57 B, p. 8, pl. 4, fig. 1; pl. 3, fig. 9.
Nodosaria evaldi Reuss, CUSHMAN, *1927*, Jour. Pal., vol. 1, p. 153, pl. 24, figs. 1, 2.

The last reference gives an illustration of this species from Mexico, where it is frequent in the Alazan.

NODOSARIA SPINICOSTA d'Orbigny

Nodosaria spinicosta D'ORBIGNY, *1846*, Foram. Foss. Vienne, p. 7, pl. 1, figs. 32, 33.—CUSHMAN, *1927*, Jour. Pal., vol. 1, p. 154, pl. 24, figs. 5, 6.

Mexican specimens of this species have been figured by Cushman. In our material small single chambered megalospheric forms are also present, which resemble rather coarsely striated forms of *Lagena striata* of authors.

NODOSARIA VERTEBRALIS (Batsch)
Plate 3, figure 9

Nautilus (Orthoceras) vertebralis BATSCH, *1791*, Conch. des Seesandes, p. 3, no. 6, pl. 2, fig. 6.
Nodosaria vertebralis (Batsch) CUSHMAN, *1919*, Carnegie Inst. Wash., Publ. 291, p. 35, pl. 7, figs. 3-5.—PLUMMER, *1926*, Univ. Texas, Bull. 2644, p. 88, pl. 5, fig. 10.—GALLOWAY AND MORREY, *1929*, Bull. Am. Pal., vol. 15, no. 55, p. 14, pl. 1, fig. 10.

Both microspheric and megalospheric forms are present, the latter with an enlarged initial chamber. The chambers are not inflated, except the last, which is sometimes separated from the others by a marked constriction. The aperture is radiate, while the number of ribs is generally ten to twelve.

NODOSARIA aff. CARINATA (Neugeboren)
Plate 3, figure 11

Dentalina carinata NEUGEBOREN, *1856,* Denkschr. K. Ak. Wiss. Wien, vol. 12, pt. 2, p. 91, pl. 4, fig. 17 (not d'Orbigny 1826).

This species is characterized by having six thin flange-like costae that extend the whole length of the test, which is circular throughout and not compressed in the later part as shown in Neugeboren's figure 17b. His form was collected from the Tertiary of Austria.

NODOSARIA RAPHANISTRUM (Linné)
Plate 3, figure 10

Nautilus raphanistrum LINNÉ, *1758,* Syst. Nat., éd. 10, p. 710.
Nodosaria raphanistrum (Linné) CUSHMAN, *1918,* U. S. Nat. Mus., Bull. 103, p. 59, pl. 21, fig. 10.—NUTTALL, *1928,* Quart. Jour. Geol. Soc., vol. 84, p. 82, pl. 4, fig 21.

Forms referred to this species are rarer than *N. vertebralis;* they are distinguished by the constrictions between adjacent chambers.

NODOSARIA cf. SOLUTA (Reuss)
Plate 3, figure 14

Dentalina soluta REUSS, *1851,* Zeitschr. Deutsch. Geol. Ges., vol. 3, p. 60, pl. 3, fig. 4.

Broken fragments of specimens resembling this species occur in the Alazan.

Genus PSEUDOGLANDULINA Cushman

PSEUDOGLANDULINA COMATULA (Cushman)

Nodosaria comatula CUSHMAN, *1923,* U. S. Nat. Mus., Bull. 104, pt. 4, p. 83, pl. 14, fig. 5.—NUTTALL, *1928,* Quart. Jour. Geol. Soc., vol. 84, p. 84, pl. 5, fig. 3.

This form is fairly finely striate, has slight constrictions for the septa, is uniserial in the initial portion, which is pointed or subacute. The aperture is stellate.

PSEUDOGLANDULINA OVATA (Cushman and Applin)
Plate 3, figure 13

Nodosaria (Glandulina) laevigata d'Orbigny var. *ovata* CUSHMAN AND APPLIN, *1926,* Bull. Am. Assn. Petroleum Geol., vol. 10, p. 169, pl. 7, figs. 12, 13.

The specimens assigned to this species have a uniserial initial portion, a large final chamber and a stellate aperture.

PSEUDOGLANDULINA CONICA (Neugeboren)

Glandulina conica NEUGEBOREN, *1850,* Verh. Mitth. Siebenburg. Ver. Nat., vol. 1, p. 51, pl. 1, fig. 5.
Glandulina radicula COLE (not Linné), *1927,* Bull. Am. Pal., vol. 14, no. 51, p. 17, pl. 3, figs. 6, 7.
Pseudoglandulina conica (Neugeboren) CUSHMAN and BARKSDALE, *1931,* Contr. Dept. Geol. Stanford Univ., vol. 1, no. 2, p. 65, pl. 12, figs. 1-3.

This species has a wide range in the Tertiary of Mexico.

Genus VAGINULINA d'Orbigny

VAGINULINA ELEGANS d'Orbigny var. MEXICANA Nuttall, n. var.
Plate 3, figures 12, 16

Var. of *Vaginulina elegans* D'ORBIGNY, *1826,* Ann. Sci. Nat., vol. 7, p. 257.—FORNASINI, *1886,* Boll. Soc. Geol. Ital., vol. 5, pl. 1, figs. 2-8; *1902,* Mem. Ac. Sci. Ist. Bologna, ser. 5, vol. 10, p. 40, fig. 32.

A considerable variety of forms have been included by authors under this species, originally described from the Adriatic. The Mexican specimens differ from the original definition of this species in having no initial spine, having more chambers and being more compressed. The strongly limbate sutures are typical, also the periphery is

generally with a narrow flange on both sides of the test. Average length 2.5 mm.

VAGINULINA ALAZANENSIS Nuttall, n. sp.
Plate 1, figures 11, 15

Test elongate, somewhat compressed; border rounded or in part with a narrow keel. Aperture radiate. Both the megalospheric and microspheric forms of the species are present, the former having a small inflated intial chamber with a single short spine, the latter being rounded anteriorly. The sutures are oblique and limbate, the amount of limbation increasing to a maximum along the median axis of the test. Width of test only increases very slowly. Length 1.3 mm.

This species is very similar to *V. eocaena* Liebus[26] (not Gümbel 1868) from the Eocene of Kärnten, which was based on a single specimen showing a more rapid increase in width of the test than in the Mexican form. The above species is distinguished from *V. elegans* d'Orbigny by being longer and having less inflated and limbate sutures.

Genus FRONDICULARIA Defrance

FRONDICULARIA ALAZANENSIS Nuttall, n. sp.
Plate 3, figure 15; plate 4, figure 1

Test compressed, large, surface smooth; periphery rounded and smooth. Megalospheric species only of this species have been observed; the primordial chamber is inflated and circular, with a diameter of about 0.3 mm. The border near the initial end is either straight or gently receding from the initial chamber. In adults there are eight or nine chambers, separated by narrow depressed sutures. The aperture is an elongated slit. Maximum observed length 3.0 mm., breadth 2.4 mm., thickness 0.25 mm.

This species appears to be most nearly related to *F. cordata* Seguenza (not Roemer),[27] which may be distinguished by the different shape of the test, the larger number of chambers, which are also proportionately narrower than in this species. Seguenza's species was described from the Tertiary of Italy.

FRONDICULARIA TENUISSIMA Hantken

Frondicularia tenuissima HANTKEN, *1875* (1876), Magyar. kir. földt. int. évkön., vol. 4, p. 36, pl. 13, fig. 11.—CUSHMAN, *1927*, Contr. Cushman Lab. Foram. Research, vol. 3, p. 111, pl. 22, fig. 11.

This species is rather rare in the Alazan.

Genus FLABELLINA d'Orbigny

FLABELLINA SEMIORNATA Nuttall, n. sp.
Plate 4, figures 2, 3

Test compressed, broadest across the last formed chamber; initial end rounded or angled, apertural end extended. Periphery with narrow irregular flange-like border. Early chambers coiled and covered with large bead-like protuberances, later chambers smooth with elevated limbate sutures. Aperture terminal, radiate. Average length 1 mm.

This species, which is rare, may be compared with some specimens of *F.*

[26] Liebus, 1927, *Jahrb. Geol. Bundesanst.*, vol. 77, p. 361, pl. 12, fig. 18.

[27] Seguenza, 1880, *Atti R. Acc. Lincei*, ser. 3, vol. 6, p. 89, pl. 9, fig. 5.

ornata Reuss, figured by Franke[28] from the Chalk.

FAMILY POLYMORPHINIDAE

Genus SIGMOIDELLA Cushman and Ozawa

SIGMOIDELLA ELEGANTISSIMA (Parker and Jones)

Polymorphina elegantissima PARKER AND JONES, *1865,* Phil. Trans., vol. 155, p. 438.
Sigmoidella elegantissima (Parker and Jones, CUSHMAN AND OZAWA, *1930,* Proc. U. S. Nat. Mus., vol. 77, art. 6, p. 140, pl. 39, fig. 1 and references.

Typical specimens of this species are present.

Genus GLOBULINA d'Orbigny

GLOBULINA INAEQUALIS Reuss

Globulina inaequalis REUSS, *1850,* Denkschr. K. Ak. Wiss. Wien, vol. 1, p. 377, pl. 48, fig. 9.—CUSHMAN AND OZAWA, *1930,* Proc. U. S. Nat. Mus., vol. 77, art. 6, p. 73, pl. 18, figs. 2-4.

The specimens are elongate, ovate and slightly compressed, the sutures not very distinct.

[28] Franke, 1928, *Abh. Preuss. Geol. Landesanst.,* N. F., vol. 3, p. 94, pl. 8, figs. 21, 22.

Genus GUTTULINA d'Orbigny

GUTTULINA IRREGULARIS (d'Orbigny)

Globulina irregularis D'ORBIGNY, *1846,* Foram. Foss. Vienne, p. 226, pl. 13, figs. 9, 10.

Guttulina irregularis (d'Orbigny) CUSHMAN, *1929,* Contr. Cushman Lab. Foram. Research, vol. 5, p. 89, pl. 13, figs. 15, 16.—CUSHMAN AND OZAWA, *1930,* Proc. U. S. Nat. Mus., vol. 77, art. 6, p. 25, pl. 3, figs. 4, 5; pl. 7, figs. 1, 2.

This species, which is considered as synonymous with *P. byramensis* Cushman, is present in the Mexican Oligocene.

Family NONIONIDAE

Genus NONION Montfort

NONION HANTKENI Cushman and Applin

Nonion hantkeni CUSHMAN AND APPLIN, *1926,* Bull. Am. Assn. Petroleum Geol., vol. 10, p. 182, pl. 10, figs. 10, 11.—CUSHMAN, *1927,* Jour. Pal., vol. 1, pl. 25, fig. 10.

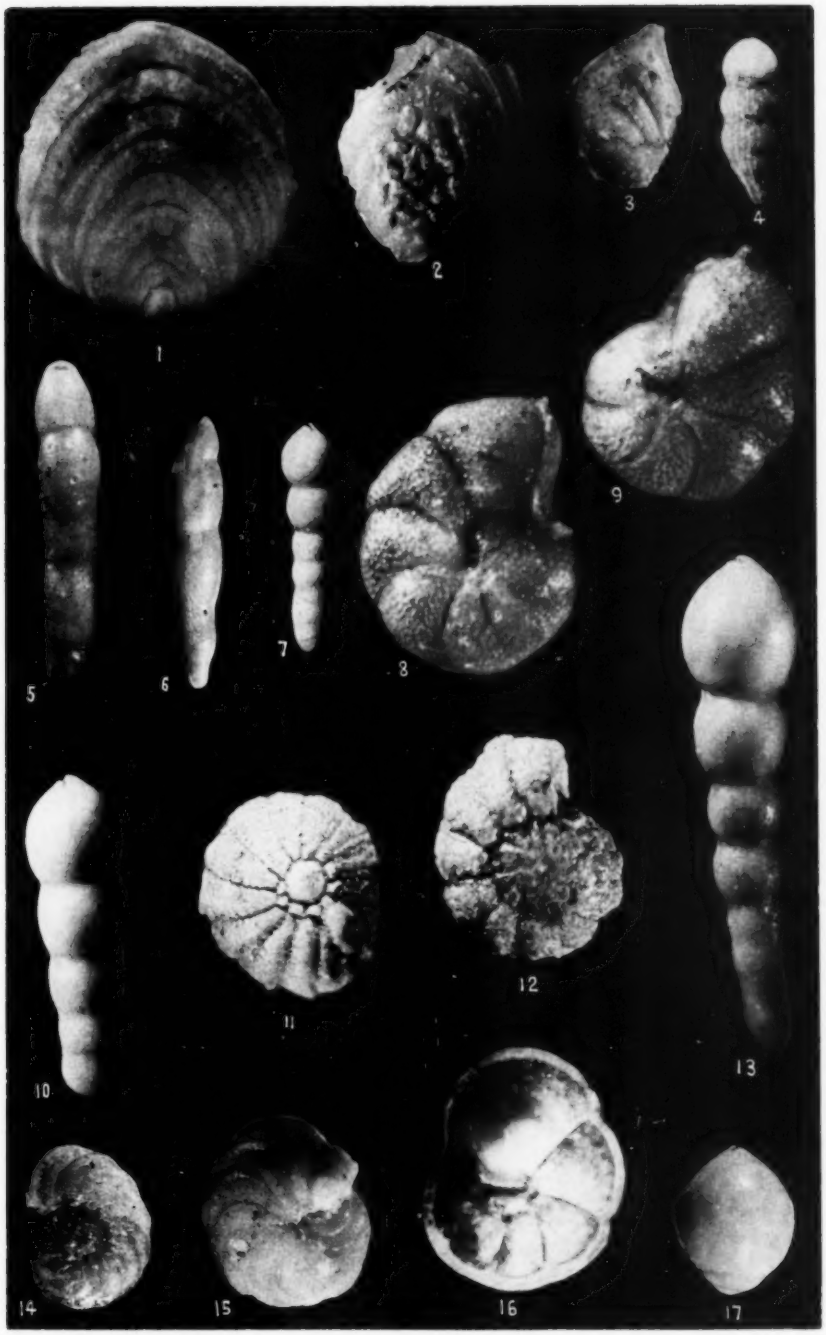
This species, which Cushman has figured from the Oligocene of Mexico, is of infrequent occurrence.

NONIONINA POMPILIOIDES (Fichtel and Moll)

Nautilus pompilioides FICHTEL AND MOLL, *1798,* Test. Micr., p. 31, pl. 2, figs. a-c.

EXPLANATION OF PLATE 4

FIGS. 1—*Frondicularia alazanensis,* Nuttall, n. sp., × 25.
2, 3—*Flabellina semiornata* Nuttall, n. sp., × 25.
4—*Ellipsoglandulina multicostata* (Galloway and Morrey), × 25.
5, 6—*Nodosarella salmojraghii* Martinotti, × 25.
7, 10, 13—*Nodosarella subnodosa* (Guppy), × 25; fig. 7, microspheric form; figs. 10, 13, megalospheric form.
8, 9—*Rotalia vicksburgensis* Cushman, × 60.
11, 12—*Rotalia mexicana* Nuttall var. *mecatepecensis* Nuttall, n. var., × 20; fig. 11, ventral view; fig. 12, dorsal view.
14, 15—*Planulina wuellerstorfi* (Schwager), × 25; fig. 14, dorsal view; fig. 15, ventral view.
16—*Globorotalia menardii* (d'Orbigny), × 69, ventral view.
17—*Ellipsoglandulina labiata* (Schwager), × 25.



Nuttall—Oligocene Foraminifera from Mexico

Nonionina pompilioides (Fichtel and Moll) BRADY, *1884,* Rep. *Challenger,* p. 727, pl. 109, figs. 10, 11.—CUSHMAN, *1929,* Contr. Cushman Lab. Foram. Research, vol. 5, p. 89, pl. 13, fig. 25.

Typical specimens of this species occur.

NONION UMBILICATULA (Montagu) var.

Nonion umbilicatula (Montagu) var. CUSHMAN, *1927,* Jour. Pal., vol. 1, p. 156, pl. 25, figs. 12, 13.

The variety figured under this name by Cushman is fairly common in the Alazan.

Family HETEROHELICIDAE

Genus PAVONINA d'Orbigny

PAVONINA MEXICANA Cushman

Pavonina mexicana CUSHMAN, *1926,* Proc. U. S. Nat. Mus., vol. 67, art. 25, p. 22, pl. 6, figs. 7-9.—CUSHMAN, *1927,* Jour. Pal., vol. 1, p. 156, pl. 25, figs. 14-16.

This is a fairly frequent species characteristic of the Alazan.

Genus PLECTOFRONDICULARIA Liebus

PLECTOFRONDICULARIA MEXICANA (Cushman)

Frondicularia mexicana CUSHMAN, *1926,* Contr. Cushman Lab. Foram. Research, vol. 1, p. 88, pl. 13, fig. 5.
Plectofrondicularia mexicana (Cushman) COLE, *1927,* Bull. Am. Pal., vol. 14, no. 51, p. 24.

This species has a wide range in the Oligocene and Eocene of Mexico.

PLECTOFRONDICULARIA VAUGHANI Cushman

Plectofrondicularia vaughani CUSHMAN, *1927,* Contr. Cushman Lab. Foram. Research, vol. 3, p. 112, pl. 23, fig. 3; *1927,* Jour. Pal., vol. 1, pl. 25, fig. 11; *1929,* Contr. Cushman Lab. Foram. Research, vol. 5, p. 92, pl. 13, figs. 21, 22.—CUSHMAN AND JARVIS, *1930,* Jour. Pal., vol. 4, p. 361, pl. 33, fig. 4.

This species is widely distributed in the Tertiary of Mexico, Trinidad, Venezuela, Ecuador, and Jamaica.

Family BULIMINIDAE

Genus BULIMINA d'Orbigny

BULIMINA OVATA d'Orbigny

Plate 2, figure 8

Bulimina ovata D'ORBIGNY, *1846,* Foram. Foss. Vienne, p. 185, pl. 11, figs. 13, 14.

The specimens are not quite as elongate as those figured by d'Orbigny.

Genus BULIMINA d'Orbigny

BULIMINA PUPOIDES d'Orbigny

Plate 2, figure 9

Bulimina pupoides D'ORBIGNY, *1846,* Foram. Foss. Vienne, p. 185, pl. 11, figs. 11, 12.—BRADY, *1884,* Rep. *Challenger,* p. 400, pl. 50, fig. 15.

The forms included under this species are fairly short and stout; the initial end is rounded or more rarely slightly pointed; the sutures are distinct and depressed. The aperture is elongate with a plate-like tooth.

BULIMINA SCULPTILIS Cushman

Plate 5, figure 1

Bulimina sculptilis CUSHMAN, *1923,* U. S. Geol. Survey, Prof. Paper 133, p. 23, pl. 3, fig. 3.

The specimens are elongate, about twice as long as broad, tapered to the acute initial end. The ornamentation consists of about ten plate-like longitudinal costae, which are continuous from one end of the test to the other. The maximum length is 1 mm. This species is identical with that found in the Red Bluff clay of Mississippi and is common in the Alazan.

BULIMINA INFLATA Seguenza
Plate 5, figure 2

Bulimina inflata SEGUENZA, *1862*, Atti. Accad. Gioenia Sci. Nat., ser. 2, vol. 18, p. 109, pl. 1, fig. 10.—CUSHMAN, *1922*, U. S. Nat. Mus., Bull. 104, pt. 3, p. 93, pl. 21, fig. 1; *1930*, Florida State Geol. Survey Bull. 4, p. 43, pl. 8, fig. 6.—COLE, *1927*, Bull. Am. Pal., vol. 14, no. 51, p. 25, pl. 3, fig. 12.—NUTTALL, *1928*, Quart. Jour. Geol. Soc., vol. 84, p. 77, pl. 3, fig. 19.—GALLOWAY AND MORREY, *1929*, Bull. Am. Pal., vol. 15, no. 55, p. 37, pl. 5, fig. 13.

The forms assigned to this species are short and stout. In America this species has previously been recorded from the Oligocene of Trinidad, the lower Tertiary of Ecuador, the Eocene of Mexico, and the Miocene of Florida.

BULIMINA TUXPAMENSIS Cole

Bulimina tuxpamensis COLE, *1928*, Bull. Am. Pal., vol. 14, no. 53, p. 12, pl. 1, fig. 23.

This species is recorded from the base only of the Lower Oligocene as well as from the Upper Eocene of the Tampico Embayment.

Genus VIRGULINA d'Orbigny

VIRGULINA NODOSA Stewart

Virgulina nodosa STEWART, *1930*, Jour. Pal., vol. 4, p. 64, pl. 8, fig. 4.

The specimens are not compressed and show the inflated chambers characteristic of this form, which was originally described from the Pliocene of California.

Genus BOLIVINA d'Orbigny

BOLIVINA ALAZANENSIS Cushman

Bolivina alazanensis CUSHMAN, *1926*, Contr. Cushman Lab. Foram. Research, vol. 1, p. 82, pl. 12, fig. 1; *1927*, Jour. Pal., vol. 1, p. 162, pl. 25, fig. 1.

In this form there is variation in the degree of thickening of the septa, as shown in the above mentioned figures.

BOLIVINA CAELATA Cushman
Plate 5, figure 3

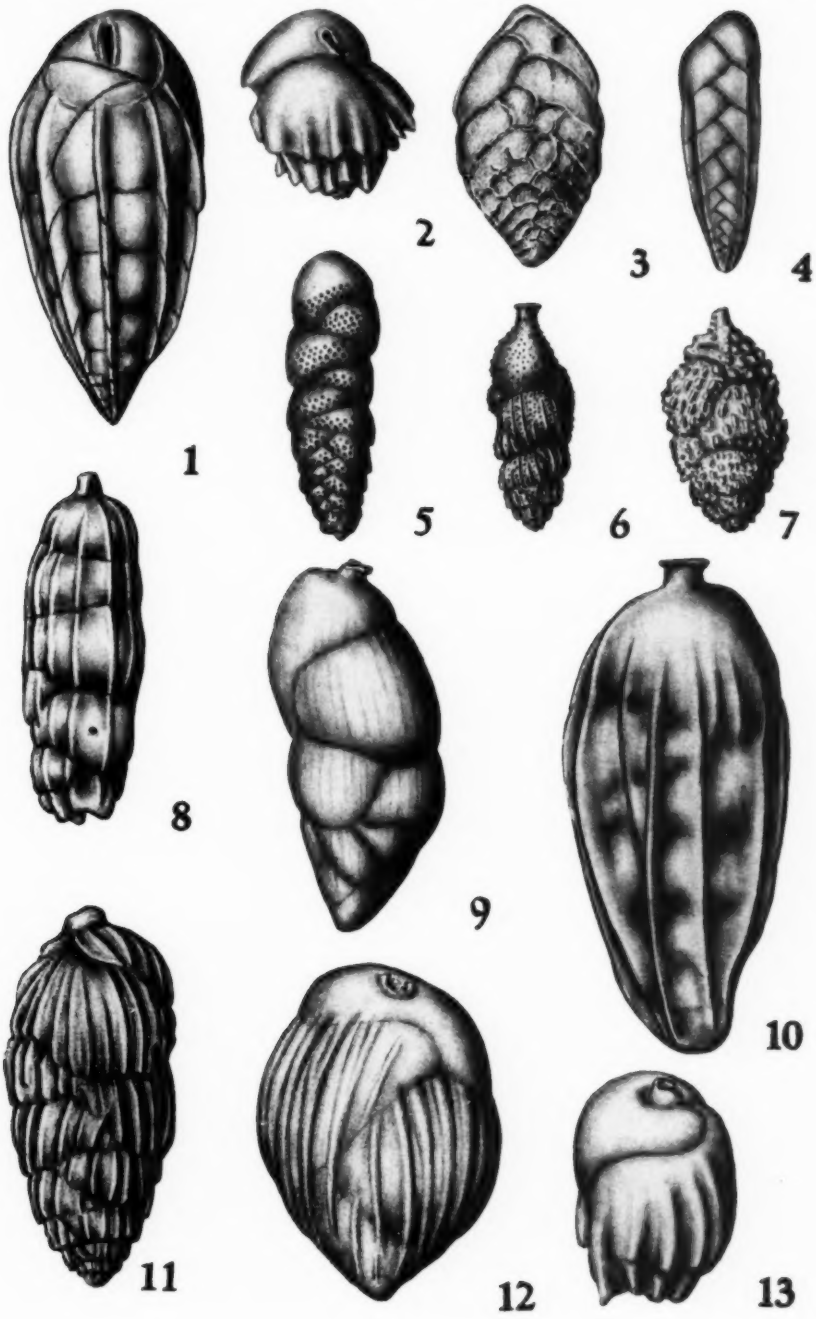
Bolivina caelata CUSHMAN, *1923*, U. S. Geol. Survey, Prof. Paper 133, p. 19, pl. 2, fig. 2; *1929*, Contr. Cushman Lab. Foram. Research, vol. 5, p. 93, pl. 13, fig. 28.

Test compressed, maximum width across the base of the last chambers. Sutures generally obscured by fine irregular reticulations, which cover all but the last two chambers, which are finely perforate. The border is acute or with a narrow flange.

This species has been recorded from the Oligocene of the Coastal Plain of the United States, Trinidad, Venezuela, and Mexico.

EXPLANATION OF PLATE 5

FIGS. 1—*Bulimina sculptilis* Cushman, × 60.
2—*Bulimina inflata* Seguenza, × 90.
3—*Bolivina caelata* Cushman, × 60.
4—*Bolivina tongi* Cushman, × 90.
5—*Bifarina vicksburgensis* (Cushman), × 90.
6—*Uvigerina pigmaea* d'Orbigny, × 60.
7—*Uvigerina auberiana* (d'Orbigny), × 60.
8—*Uvigerina tenuistriata* Reuss, × 60.
9—*Uvigerina canariensis* d'Orbigny var., × 60.
10—*Uvigerina alazanensis*, Nuttall, n. sp., × 60.
11—*Uvigerina gardnerae* Cushman and Applin, var., × 60.
12, 13—*Uvigerina mexicana* Nuttall, n. sp., × 60.



Nuttall—Oligocene Foraminifera from Mexico

GALLOWAY AND WISSLER, *1927,* Jour. Pal., vol. 1, p. 75, pl. 11, fig. 22.—NUTTALL, *1928,* Quart. Jour. Geol. Soc., vol. 84, p. 94, pl. 6, fig. 16.—CUSHMAN, *1929,* Contr. Cushman Lab. Foram. Research, vol. 5, p. 95, pl. 13, fig. 36; *1930,* Florida State Geol. Survey, Bull. 4, p. 49, pl. 9, fig. 7.—CUSHMAN AND JARVIS, *1930,* Jour. Pal., vol. 4, p. 363, pl. 33, figs. 9, 10.

This species is widely distributed in the Tertiary of America.

UVIGERINA CANARIENSIS d'Orbigny var.
Plate 5, figure 9

Uvigerina canariensis D'ORBIGNY, *1839,* in Barker, Webb and Berthelot, Hist. Nat. Iles Canaries, vol. 2, pt. 2, "Foraminifères," p. 138, pl. 1, figs. 25-27.—BRADY, *1884,* Rep. *Challenger,* p. 573, pl. 74, figs. 1-3.

Varietal forms of this species show considerable variation in shape; some are short and stout with the initial portion rounded, while others are more elongate and tapered to a blunt point. The surface is either quite smooth or with very fine longitudinal striae. The aperture is generally in a slight depression with a cylindrical lipped neck.

UVIGERINA ALAZANENSIS Nuttall, n. sp.
Plate 5, figure 10

Test elongate, fusiform, subcylindrical or tapered, broadest at the base of the last chamber. Sutures indistinct, except in the last few chambers which are somewhat inflated with depressed sutures. Last chamber smooth. Remainder of test with twelve or more narrow plate-like costae, most of which extend the whole length of the test and join at the initial end, which is subacute or rounded. The aperture consists of a short tubular neck with a flaring lip sometimes situated in a slight depression. Average length 1.2 mm., width 0.5 to 0.6 mm.

This is a very common form in the Alazan. It is distinguished from *U. jacksonensis* Cushman[29] by being more elongate and tapering, also the costae are more continuous from one chamber to the next. *U. gallowayi* Cushman,[30] with paratypes of which it has been compared, may be distinguished by its short spinose projections towards the initial end and by being less tapered.

UVIGERINA GARDNERAE Cushman and Applin var.
Plate 5, figure 11

Uvigerina gardnerae CUSHMAN AND APPLIN, Bull. Am. Assn. Petroleum Geol., vol. 10, p. 175, pl. 8, figs. 16, 17.

The Mexican specimens have numerous thick costae, which are not continuous from one chamber to the next. The earlier chambers overhang those preceding and the spinose development near the aperture is very variable, being absent in some specimens. Length 0.8 to 1 mm.

The original figures of this species are poor. A comparison with specimens from the Jackson of Texas shows that the costae in the Mexican form are coarser and the spinose development near the aperture less well developed and constant.

UVIGERINA MEXICANA Nuttall, n. sp.
Plate 5, figures 12, 13

Test short, stout, earlier portion pointed or subacute, broadest at about one-third the total distance from the apertural end. Initial two-thirds of the

[29] Cushman, 1925, *Contr. Cushman. Lab. Foram. Research,* vol. 1, p. 67, pl. 10, fig. 13.
[30] Cushman, 1929, *idem.,* vol. 5, p. 94, pl. 13, figs. 33, 34.

test with sutures indistinct, covered with numerous longitudinal costae, which are continuous from one chamber to another. Costae gradually becoming absent in the later part of the test, the last chambers being smooth and inflated, separated by distinct depressed sutures. Aperture a very short tube in a depressed or flattened area of the last chamber. Average length 0.7 mm.

This species resembles *U. semiornata* d'Orbigny[31] from which it may be distinguished by its different costae and aperture. *U. beccarii* Fornasini[32] has much fewer costae.

UVIGERINA SPINICOSTATA Cushman and Jarvis var. ALAZANENSIS Nuttall, n. var.

Plate 6, figure 1

Var. of *Uvigerina spinicostata* CUSHMAN and JARVIS, *1929*, Contr. Cushman Lab. Foram. Research, vol. 5, p. 12, pl. 3, figs. 9, 10.

Variety differing from the typical in the test being proportionately somewhat shorter and stouter, in the apertural neck being narrower and in the costae being less numerous. Average length 1.1 mm., width 0.5 mm.

Family ELLIPSOIDINIDAE

Genus NODOSARELLA Rzehak

Confusion exists as to the priority and use of the generic terms *Nodosarella* and *Ellipsonodosaria*. The former was proposed by Rzehak and the genotype designated by Cushman as *Lingulina tuberosa* Gümbel. The latter name was proposed by Silvestri with *Lingulina rotundata* d'Orbigny as genotype.

Cushman[33] states that *Nodosarella* has "the early chambers showing traces of biserial ancestry," a feature which is not indicated in Gümbel's figure of *L. tuberosa*. In fact, in the original figures of this species and in *L. rotundata* the chambers appear uniserial. Galloway and Morrey[34] considered *Nodosarella* and *Ellipsonodosaria* as synonymous, the former having priority, which view was previously expressed by Martinotti[35] and is also the writer's opinion.

Martinotti has also shown that in the megalospheric form of *Nodosarella rotundata* (d'Orbigny) the chambers are uniserial, while in the microspheric form the earlier portion is biserial.

NODOSARELLA SALMOJRAGHII Martinotti

Plate 4, figures 5, 6

Nodosarella salmojraghii MARTINOTTI, *1923*, Atti. Soc. Ital. Sci. Nat., vol. 62, p. 347, pl. 7, figs. 58-60; text fig. 28.—COLE, *1928*, Bull. Am. Pal., vol. 14, no. 53, p. 13, pl. 1, fig. 6.

In this form an initial biserial portion is faintly discernible, while the aperture is broad and elliptical. The test is smaller than in *N. subnodosa* and the shape of aperture different, being smaller and facing one side. The poorness of the original illustrations of this form render specific determination not quite certain. Cole's figure is of a

[31] d'Orbigny, 1846, *Foram. Foss. Vienne*, p. 189, pl. 11, fig. 23, 24.

[32] Fornasini, 1898, *Riv. Acc. Sci. Bologna*, vol. 2, p. 12, pl. 1, fig. 5.

[33] Cushman, 1928, *The Foraminifera*, p. 261.

[34] Galloway and Morrey, 1929, *Bull. Am. Pal.*, vol. 15, no. 55, p. 40.

[35] Martinotti, 1923, *Atti. Soc. Ital. Sci. Nat.*, vol. 62, p. 345-346, pl. 7, figs. 54-57.

short stout specimen from the Chapapote.

NODOSARELLA SUBNODOSA (Guppy)
Plate 4, figures 7, 10, 13

Ellipsoidina subnodosa GUPPY, *1894*, Proc. Zool. Soc. Lond., p. 650, pl. 61, fig. 12.
Ellipsonodosaria subnodosa (Guppy) NUTTALL, *1928*, Quart. Jour. Geol. Soc. Lond., vol. 84, p. 95, pl. 6, fig. 20.
Nodosarella rotundata COLE (not d'Orbigny), *1928*, Bull. Am. Pal., vol. 14, no. 53, p. 14, pl. 3, fig. 13.

The specimens are the same as in the Tertiary of Trinidad, and Cole's figure appears to be of this form, which also occurs in the Chapapote of Mexico. Cushman[36] has figured specimens referred to this species from the Cretaceous of Trinidad, which are shorter and stouter and probably distinct. Both megalospheric and microspheric forms of this species are found associated, the latter showing a biserial arrangement of only the earlier chambers.

NODOSARELLA PAUCISTRIATA Galloway and Morrey

Nodosarella paucistriata GALLOWAY AND MORREY, *1929*, Bull. Am. Pal., vol. 15, no. 55, p. 42, pl. 6, fig. 12.

[36]Cushman, 1928, *Contr. Cushman Lab. Foram. Research*, vol. 4, p. 102, pl. 14, figs. 15, 16.

Ellipsonodosaria verneuili (d'Orbigny) var. *paucistriata* (Galloway and Morrey) CUSHMAN, *1929*, Contr. Cushman Lab. Foram. Research, vol. 5, p. 97, pl. 14, figs. 4, 5.

Only broken specimens of this species have been observed.

Genus ELLIPSOGLANDULINA Silvestri

ELLIPSOGLANDULINA LABIATA (Schwager)
Plate 4, figure 17

Glandulina labiata SCHWAGER, *1866*, Novara Exped., Geol. Theil, pt. 2, p. 237, pl. 6, fig. 77.
Ellipsoglandulina labiata (Schwager) MARTINOTTI, *1923*, Atti. Soc. Ital. Sci. Nat., vol. 62, p. 343, pl. 7, fig. 53; text figs. 25-27.—SILVESTRI, *1923*, Mem. Pont. Acc. Rom. N. Lincei, Ser. 2, vol. 6, p. 256.—MARTINOTTI, *1925*, Atti. Soc. Ital. Sci. Nat., vol. 64, p. 178, pl. 4, figs. 13-17.

The specimens are globular with a large final chamber, two of the earlier chambers being visible. The aperture is crescentric.

ELLIPSOGLANDULINA MULTICOSTATA (Galloway and Morrey)
Plate 4, figure 4

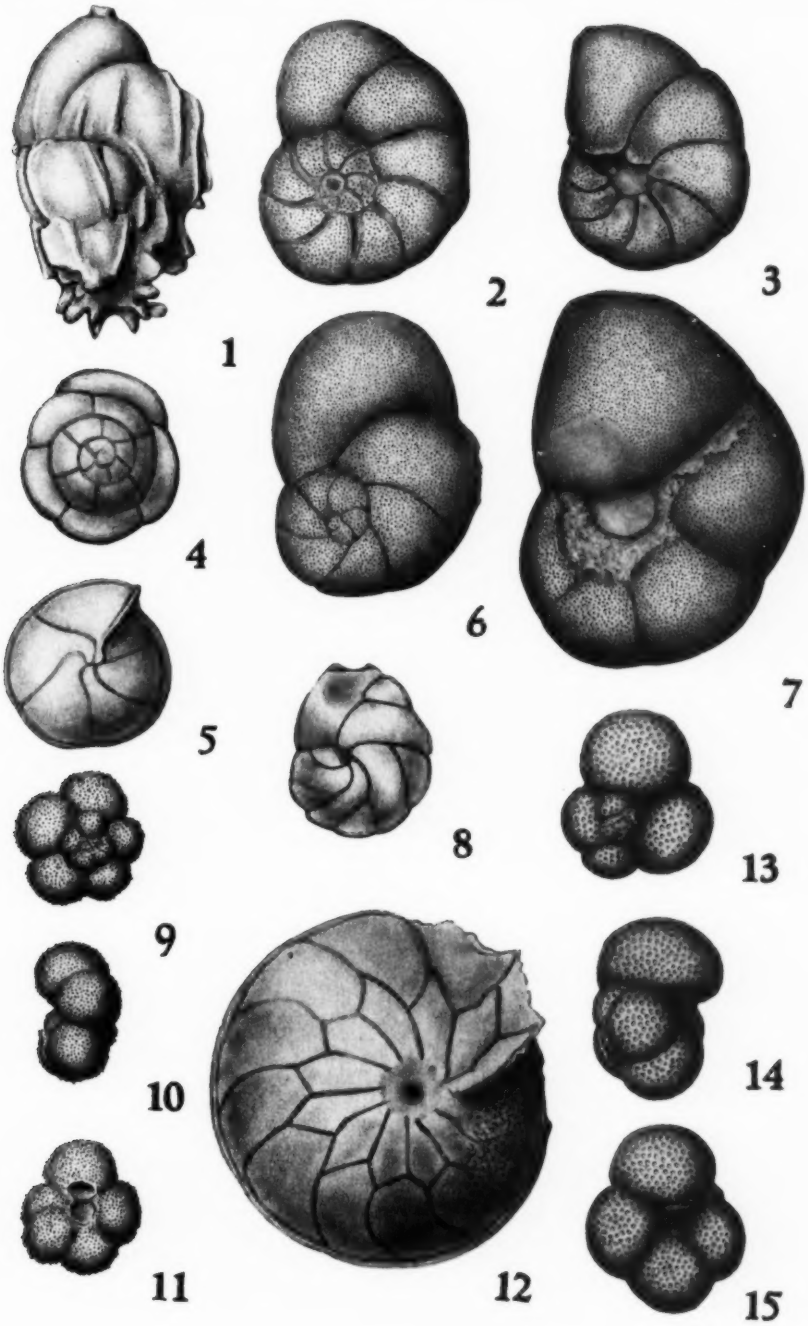
Daucina multicostata GALLOWAY AND MORREY, *1929*, Bull. Am. Pal., vol. 15, no. 55, p. 42, pl. 6, fig. 13.

Typical specimens of this species occur.

The writer is not of the opinion that

EXPLANATION OF PLATE 6

FIGS. 1—*Uvigerina spinicostata* Cushman and Jarvis, var. *alazanensis* Nuttall, n. var., × 60.
2, 3—*Discorbis araucana* (d'Orbigny), × 60; fig. 2, dorsal view; fig. 3, ventral view.
4, 5—*Eponides umbonata* (Reuss), × 60; fig. 4, dorsal view; fig. 5, ventral view.
6, 7—*Cancris sagra* (d'Orbigny), × 60; fig. 6, dorsal view; fig. 7, ventral view.
8—*Cassidulina laevigata* d'Orbigny var. *carinata* Cushman, × 60, side view.
9-11—*Globigerina concinna* Reuss, × 60; fig. 9, dorsal view; fig. 10, side view; fig. 11, ventral view.
12—*Amphistegina lessoni* d'Orbigny, × 40, ventral view.
13-15—*Globigerina bulloides* d'Orbigny, × 60; fig. 13, dorsal view; fig. 14, side view; fig. 15, ventral view.



Nuttall—Oligocene Foraminifera from Mexico

Daucina is synonymous with and has priority over *Ellipsoglandulina,* the two genera being considered distinct. He is indebted to Dr. Mcfadyen for extracting the reference to the scarce publication in which Bornemann's[87] description of *Daucina* appeared, the more important part of which reads as follows:

> Die Öffnung befindet sich auf der Mitte des letzen Kammer; ihre Form ist unregelmässig, meist dreilappig. Die Nähte sind wenig vertieft und bilden in sich selbst zurücklaufende Curven, welche zweimal gegen eine die Mitte ihrer Oberfläche berührende, Ebene an- und absteigen. Es bilden sich auf diese Weise in jeder Nähtlinie zwei Sättel, welche mit denen der zunächst gelegenen Näht alterniren.

The figures show clearly the triple-lobed aperture, which is quite different from the crescentic opening of *Ellipsoglandulina.* In addition the sutural curvatures are a feature peculiar to *Daucina.*

Family Rotaliidae

Genus Discorbis Lamarck

Discorbis araucana (d'Orbigny)

Plate 6, figures 2, 3

Rosalina araucana d'Orbigny, *1839,* Voy. Amer. Merid. vol. 5, pt. 5, p. 44, pl. 6, figs. 16-18.

Discorbis araucana (d'Orbigny) Brady, *1884,* Rep. *Challenger,* p. 645, pl. 86, figs. 10, 11.—Cushman, *1922,* U. S. Geol. Survey, Prof. Paper 129 F, p. 135, pl. 32, fig. 6.

In the specimens examined, both sides are slightly convex, the dorsal more than the ventral. The border is narrow. On the ventral surface the aperture is protected by a sheath-like extension, the sutures are limbate and gently curved. Dorsally the sutures are limbate and slightly elevated, the chambers on both sides being fairly coarsely perforate.

[87] Bornemann, 1855, *Erman's Archiv für Wiss. Kunde von Russland,* vol. 14, p. 153.

Genus Gyroidina d'Orbigny

Gyroidina girardana (Reuss)

Rotalina girardana Reuss, *1851,* Zeitschr. Deutsch. Geol. Ges., vol. 3, p. 73, pl. 5, fig. 34.

Gyroidina girardana (Reuss) Cushman, *1927,* Jour. Pal., vol. 1, p. 164, pl. 25, figs. 7-9.

Specimens of this species from Mexico have been figured by Cushman.

Gyroidina soldanii d'Orbigny

Gyroidina soldanii d'Orbigny, *1826,* Ann. Sci. Nat., vol. 7, p. 278. no. 5; modèle no. 36.

The specimens present in the Alazan have a fairly sharp border and numerous narrow chambers separated by oblique septa. It is common throughout the Oligocene in Mexico.

Gyroidina broeckhiana (Karrer)

Rotalia broeckhiana Karrer, *1878,* In v. Drasche, Frag. Geol. Luzon, p. 98, pl. 5, fig. 26.—Brady, *1884,* Rep. *Challenger,* p. 705, pl. 107, fig. 4.

The specimens assigned to this species have the spire only slightly elevated.

Genus Rotalia Lamarck

Rotalia vicksburgensis Cushman

Plate 4, figures 8, 9

Rotalia vicksburgensis Cushman, *1923,* U. S. Geol. Survey, Prof. Paper 129, p. 139, pl. 35, figs. 3, 4; *1923,* U. S. Geol. Survey, Prof. Paper 133, p. 46.

Gyroidina vicksburgensis (Cushman) Cole and Ponton, *1930,* Florida State Geol. Survey, Bull. 5, p. 41.

Specimens of this species occur agreeing with Cushman's description

and figures. The test is finely perforate and the aperture consists of an arched elongate opening extending from near the periphery about half way towards the center of the test. The umbilical area has no plug of clear shell substance, but the species is not typical of *Gyroidina*.

ROTALIA MEXICANA Nuttall
var. MECATEPECENSIS Nuttall, n. var.

Plate 4, figures 11, 12

Var. of *Rotalia mexicana* NUTTALL, *1928*, Jour. Pal., vol. 2, p. 374, pl. 50, figs. 6-8.
Rotalia sp. CUSHMAN, *1927*, Jour. Pal., vol. 1, p. 166, pl. 26, fig. 5.

This variety differs slightly from the species described from the Upper Eocene of southern Mexico. It is distinguished by the dorsal surface which, instead of being smooth, is somewhat roughened, with the last coil visible. It differs from *R. byramensis* Cushman in that the chambers of the latter are fewer in number and towards the periphery more extended towards the projecting portions.

Genus EPONIDES Montfort

EPONIDES BYRAMENSIS Cushman

Pulvinulina byramensis CUSHMAN, *1922*, U. S. Geol. Survey, Prof. Paper 129, p. 99, pl. 22, figs. 4, 5.
Eponides byramensis (Cushman) COLE AND GILLISPIE, *1930*, Bull. Am. Pal., vol. 15, no. 57 B, p. 12, pl. 2, figs. 1, 2.

This species, which is common in the Meson, occurs rarely in the Alazan.

EPONIDES AFFINIS (Czjzek)

Rotalina affinis CZJZEK, *1848*, Haidinger's Nat. Abh., vol. 2, p. 144, pl. 12, figs. 36-38.
Eponides affinis (Czjzek) CUSHMAN AND LAIMING, *1931*, Jour. Pal., vol. 5, p. 114, pl. 13, fig. 8.

Test biconvex, rotaliform, the dorsal side slightly elevated, border narrow. Whorls on dorsal surface rather indistinct, sutures oblique, about seven chambers in the last whorl. Ventrally with some secondary shell substance and a depression at the umbilicus. Aperture an elongate narrow slit at the base of the last chamber on the ventral surface. The specimens are very similar to the form figured by Cushman from the Miocene of California.

EPONIDES UMBONATA (Reuss)

Plate 6, figures 4, 5

Rotalina umbonata REUSS, *1851*, Zeitschr. Deutsch. Geol. Ges., vol. 3, p. 75, pl. 5, fig. 35.
Pulvinulina umbonata (Reuss) HANTKEN, *1875* (1876), Magyar kir. földt. int. évkön, vol. 4, p. 67, pl. 9, fig. 8.
Eponides umbonata (Reuss) CUSHMAN, *1929*, Contr. Cushman Lab. Foram. Research, vol. 5, p. 98, pl. 14, fig. 8 (and references).

The specimens from the Alazan have the characteristic curvature of the sutures on the ventral surface, as in Cushman's illustration of a specimen from the type locality in Germany.

Genus EPISTOMINA Terquem

EPISTOMINA ELEGANS (d'Orbigny)

Rotalia (Turbinulina) elegans D'ORBIGNY, *1826*, Ann. Sci. Nat., vol. 7, p. 276, no. 54.
Epistomina elegans (d'Orbigny) CUSHMAN, *1927*, Jour. Pal., vol. 1, p. 166, pl. 26, figs. 3, 4; *1927*, Contr. Cushman Lab. Foram. Research, vol. 3, p. 182, pls. 31, 32 and references.

The second reference refers to Cushman's figure of this species from the type locality of the Alazan in the Rio Buenavista.

Genus SIPHONINA Reuss

SIPHONINA TENUICARINATA Cushman

Siphonina tenuicarinata CUSHMAN, *1927*, Jour. Pal., vol. 1, p. 166, pl. 26, figs. 11, 12;

1929, Contr. Cushman Lab. Foram. Research, vol. 5, p. 100, pl. 14, fig. 9.—COLE, *1927,* Bull. Am. Pal., vol. 14, no. 51, p. 30, pl. 5, figs. 1, 2.

This species has a wide range in the Mexican Lower Tertiary.

Genus CANCRIS Montfort

CANCRIS SAGRA (d'Orbigny)

Plate 6, figures 6, 7

Rotalina sagra D'ORBIGNY, *1839,* in de La Sagra, Hist. Phis. Pol. Nat. Cuba, "Foraminifères," p. 77, pl. 5, figs. 13-15.

Pulvinulina sagra (d'Orbigny) CUSHMAN, *1918,* U. S. Geol. Survey, Bull. 676, p. 65, pl. 22, fig. 3; pl. 23, fig. 1; *1918,* U. S. Nat. Mus., Bull. 103, p. 70, pl. 24, fig. 6; *1923,* U. S. Geol. Survey, Prof. Paper 133, p. 45, pl. 6, figs. 9, 10.

Cancris sagra (d'Orbigny) CUSHMAN, *1930,* Florida State Geol. Survey, Bull. 4, p. 56, pl. 11, fig. 4; *1931,* Jour. Pal., vol. 5, p. 115, pl. 14, fig. 3.

This species, found in the Alazan of Mexico, is recorded from the Miocene and Oligocene of U.S.A.

Family AMPHISTEGINIDAE

Genus AMPHISTEGINA d'Orbigny

AMPHISTEGINA LESSONI d'Orbigny

Plate 6, figure 12

Amphistegina lessoni D'ORBIGNY, *1826,* Ann. Sci. Nat., vol. 7, p. 304, pl. 17, figs. 1-4.—CUSHMAN, *1930,* Florida State Geol. Survey, Bull. 4, p. 57, pl. 11, fig. 5; *1931,* U. S. Nat. Mus., Bull. 104, pt. 8, p. 79, pl. 16, figs. 1-3.

Test equally biconvex, lenticular, border narrow. Both sides with a large slightly raised central boss of clear shell substance. Dorsal surface smooth, glossy; sutures flush with the chamber surfaces, curved with an angled sinuosity at about one third of their length from the center. One whorl only visible with about 13-16 chambers. Chamber surface very finely perforate, sutures of clear shell material. Ventral surface with sutures joining to form an angle at about half the distance between the center and the periphery. Aperture narrow at the inner border of the last chamber. The quadrant of the ventral surface facing the aperture is frequently covered with small papillae. Average diameter 1.2 mm.

Family CASSIDULINIDAE

Genus CERATOBULIMINA Toula

CERATOBULIMINA ALAZANENSIS Cushman and Harris

Ceratobulimina alazanensis CUSHMAN AND HARRIS, *1927,* Contr. Cushman Lab. Foram. Research, vol. 3, p. 174, pl. 29, figs. 5a-c; pl. 30, figs. 3-5.

This species is fairly common in the lower part of the Mexican Oligocene.

Genus PULVINULINELLA Cushman

PULVINULINELLA (?) CULTER var. MEXICANA Cole

Pulvinulinella culter var. *mexicana* COLE, *1927,* Bull. Am. Pal., vol. 14, no. 51, p. 31, pl. 1, figs. 15, 16.—NUTTALL, *1930,* Jour. Pal., vol. 4, p. 293 and references.

This species ranges down to the Aragon.

Genus CASSIDULINA d'Orbigny

CASSIDULINA LAEVIGATA d'Orbigny var. CARINATA Cushman

Plate 6, figure 8

Cassidulina laevigata d'Orbigny var. *carinata* CUSHMAN, *1922,* U. S. Nat. Mus., Bull. 104, pt. 3, p. 124, pl. 25, figs. 6, 7; *1930,* Florida State Geol. Survey, Bull. 4, p. 58, pl. 11, fig. 7.—CUSHMAN and PARKER, *1931,* Contr. Cushman Lab. Foram. Research, vol. 7, p. 14, pl. 2, fig. 14.

This species, previously recorded as living in the Atlantic and from the Miocene of Florida and California, is rare in the Alazan shale.

CASSIDULINA SUBGLOBOSA Brady

Cassidulina subglobosa BRADY, *1884,* Rep. *Challenger,* p. 430, pl. 54, fig. 17.—CUSHMAN, *1925,* Contr. Cushman Lab. Foram. Research, vol. 1, p. 54, pl. 8, figs. 48-50; *1929,* Contr. Cushman Lab. Foram. Research, vol. 5, p. 100, pl. 14, fig. 11.—NUTTALL, *1928,* Quart. Jour. Geol. Soc., vol. 84, p. 78.—GALLOWAY AND MORREY, *1929,* Bull. Am. Pal., vol. 15, no. 55, p. 40, pl. 6, fig. 6.

Forms indistinguishable from this living species occur in the Alazan. In the basal Oligocene, Chapapote and Guayabal a closely related species is present, which has been referred to *C. globosa* Hantken by Cushman and Cole. The above species has been recorded from the Lower Tertiary of Ecuador, Venezuela and Trinidad.

Genus EHRENBERGINA Reuss

EHRENBERGINA SEMMESI Cushman

Ehrenbergina semmesi CUSHMAN, *1927,* Proc. U. S. Nat. Mus., vol. 70, art. 16, p. 2, pl. 1, fig. 1.

This species occurs sparingly in the Alazan.

Family CHILOSTOMELLIDAE

Genus CHILOSTOMELLA Reuss

CHILOSTOMELLA OVOIDEA Reuss

Chilostomella ovoidea REUSS, *1850,* Denkschr. Ak. Wiss. Wien, vol. 1, p. 380, pl. 48, fig. 12.—CUSHMAN, *1926,* Contr. Cushman Lab. Foram. Research, vol. 1, p. 74, pl. 11, fig. 1.—COLE, *1928,* Bull. Am. Pal., vol. 14, no. 53, p. 20, pl. 2, fig. 10.

Cole has figured this form from the Chapapote, his specimens showing a short aperture. Specimens from the Oligocene appear indistinguishable from Reuss' species.

Genus CHILOSTOMELLOIDES Cushman

CHILOSTOMELLOIDES OVIFORMIS (Sherborn and Chapman)

Lagena (Obliquina) oviformis SHERBORN AND CHAPMAN, *1886,* Jour. Roy. Micr. Soc., vol. 6, p. 745, pl. 14, fig. 19.

Chilostomelloides oviformis (Sherborn and Chapman) CUSHMAN, *1926,* Contr. Cushman Lab. Foram. Research, vol. 1, p. 77, pl. 11, figs. 17, 21; *1927,* Jour. Pal., vol. 1, p. 168, pl. 26, fig. 10.—COLE, *1928,* Bull. Am. Pal., vol. 14, no. 53, p. 16.—NUTTALL, *1930,* Jour. Pal., vol. 4, p. 289.

This species ranges down into the Aragon.

Genus PULLENIA Parker and Jones

PULLENIA SPHAEROIDES (d'Orbigny)

Nonionina sphaeroides D'ORBIGNY, *1826,* Ann. Sci. Nat., vol. 7, p. 293, no. 1; modèle no. 43.

Pullenia sphaeroides (d'Orbigny) BRADY, *1884,* Rep. *Challenger,* p. 615, pl. 84, figs. 12, 13 and references.—CUSHMAN, *1924,* U. S. Nat. Mus., Bull. 104, pt. 5, p. 40, pl. 8, figs. 3, 4.

Pullenia bulloides (d'Orbigny) GALLOWAY AND MORREY, *1929,* Bull. Am. Pal., vol. 15, no. 55, p. 43, pl. 6, fig. 16.

Typical specimens of this species are present.

PULLENIA QUINQUELOBA (Reuss)

Nonionina quinqueloba REUSS, *1851,* Zeitschr. Deutsch. Geol. Ges., vol. 3, p. 71, pl. 5, fig. 31.

Pullenia quinqueloba (Reuss) BRADY, *1884,* Rep. *Challenger,* p. 617, pl. 84, figs. 14, 15.—GALLOWAY AND MORREY, *1929,* Bull. Am. Pal., vol. 15, no. 55, p. 44, pl. 6, fig. 17.

The specimens have a fairly well rounded border. The form named *P. alazanensis* Cushman,[38] with deep punctae on the apertural face is also present but rare.

[38] Cushman, 1927, *Jour. Pal.,* vol. 1, p. 168, pl. 26, figs. 14, 15.

Genus SPHAEROIDINA d'Orbigny

SPHAEROIDINA BULLOIDES d'Orbigny

Sphaeroidina bulloides D'ORBIGNY, *1826,* Ann. Sci. Nat., vol. 7, p. 267, no. 1, modèle no. 65.—BRADY, *1884,* Rep. *Challenger,* p. 620, pl. 84, figs. 1-7.

There appears to be no reliable method of distinguishing this species from *S. variabilis* Reuss and *S. austriaca* d'Orbigny, which has been classified by Brady as synonymous. Cushman also considers that they may be identical.[39]

Family GLOBIGERINIDAE

Genus GLOBIGERINA d'Orbigny

GLOBIGERINA CONCINNA Reuss
Plate 6, figures 9-11

Globigerina concinna REUSS, *1850,* Denkschr. K. Ak. Wiss. Wien, vol. 1, p. 373, pl. 47, fig. 8.

On the dorsal surface the spire is slightly elevated, the chambers distinct and globular, about twelve being visible. Ventrally the last whorl consists of five chambers with a central cavity into which apertures of the last chambers open. This form differs from the species referred to below as *G. bulloides* chiefly in having more chambers, the apertural characters being similar. Diameter 0.3 mm.

This species was originally described from the Miocene of Austria, and Fornasini figured a similar form from the Adriatic.[40]

GLOBIGERINA BULLOIDES d'Orbigny
Plate 6, figures 13-15

The uncertainty as to the correct interpretation of this species renders identification uncertain. The Alazan specimens resemble Brady's[41] figures of this form in being convex on the upper surface with seven or eight visible chambers, while on the ventral surface only four chambers can be seen in the last whorl. The apertures open into the central cavity, the opening into the last chamber being the most conspicuous. Average diameter 0.4 mm.

GLOBIGERINA cf. APERTURA Cushman
Plate 8, figures 1-3

Globigerina apertura CUSHMAN, *1918,* U. S. Geol. Survey, Bull. 676, p. 57, pl. 12, fig. 8.

Test thick, dorsally with chambers of earlier whorls indistinct, four chambers in the last whorl. Ventrally with a central cavity into which open the apertures of the last whorl of chambers; this opening is sometimes partly covered by the overlapping part of the chambers. Average diameter 0.5 mm.

This form differs from the above species in the shape and smaller size of the aperture.

Family GLOBOROTALIDAE

Genus GLOBOROTALIA Cushman

GLOBOROTALIA MENARDII (d'Orbigny)
Plate 4, figure 16

Rotalia menardii D'ORBIGNY, *1826,* Ann. Sci. Nat., vol. 7, p. 273, no. 26, modèle no. 10.
Pulvinulina menardii (d'Orbigny) BRADY, *1884,* Rep. *Challenger,* p. 690, pl. 103, figs. 1, 2.—CUSHMAN, *1923,* U. S. Geol. Survey, Prof. Paper 133, p. 45.—NUTTALL, *1928,* Quart. Jour. Geol. Soc., Vol. 84, p. 101, pl. 7, fig. 20.
Globorotalia menardii (d'Orbigny) CUSHMAN, *1930,* Florida State Geol. Survey, Bull. 4, p. 60, pl. 12, fig. 1.

[39] Cushman 1929, *Contr. Cushman, Lab. Foram. Research,* vol. 5, p. 101.

[40] Fornasini, 1899, *Mem. Ac. Sci. Ist. Bologna,* ser. 5, vol. 7, p. 6, pl. 1, figs. 6-9; pl. 2, fig. 2.

[41] Brady, 1884, *Rep.* Challenger, p. 593, pl. 79, figs. 3-7.

The specimens examined are small and convex on the ventral surface, the dorsal side being nearly flat. The periphery is lobate and carinate. There are seven chambers in the last whorl. Dorsally the sutures are limbate and elevated, while ventrally they are depressed. The aperture is protected by a valvular lip. Diameter 0.5 mm.

GLOBOROTALIA PALMAREALENSIS Nuttall, n. sp.
Plate 7, figures 1-3

Test compressed, both sides slightly elevated, ventral surface somewhat more convex, periphery angled or rounded. Dorsally smooth with two whorls visible. Sutures narrow, not raised, gently curved, nine chambers in the last whorl. Ventrally smooth, sutures straight, depressed. Each chamber terminating internally with an extended thickened projection of clear shell substance. The last chamber with an overhanging lip, obscuring the aperture which opens into the umbilicus and extends to near the periphery on the ventral surface. Chamber surfaces finely perforate. Diameter 0.7 mm., thickness 0.2 mm.

There appears to be no described species with which this form can be closely compared.

FAMILY ANOMALINIDAE

Genus ANOMALINA d'Orbigny

ANOMALINA GROSSERUGOSA (Gümbel)

Truncatulina grosserugosa GÜMBEL, *1868*, Abh. m. ph. cl. K. Bayer, Ak. Wiss., vol. 10, p. 660, pl. 2, fig. 104.
Anomalina grosserugosa (Gümbel) CUSHMAN, *1923*, U. S. Geol. Survey, Prof. Paper 133, p. 43.—NUTTALL, *1928*, Quart. Jour. Geol. Soc., vol. 84, p. 99, pl. 7, figs. 18, 19 and references.—COLE, *1928*, Bull. Am. Pal., vol. 14, no. 53, p. 18, pl. 1, figs. 16, 17.

This species has been observed in the Upper Eocene and Lower Oligocene of Mexico.

ANOMALINA MECATEPECENSIS Nuttall, n. sp.
Plate 7, figures 4, 6

Test rotaliform, compressed. Ventral surface flat or slightly elevated. Dorsal surface convex, periphery narrow, lobate. Dorsally with two visible whorls, the first small and obscured by growth of secondary shell substance. The last whorl with elevated thick limbate gently curved sutures, about fifteen or sixteen chambers with coarsely perforate walls. Ventrally the sutures are similar to those of the dorsal surface and where they unite at the center is an area of clear shell substance. The periphery has a narrow beaded border. The aperture is narrow and reaches

EXPLANATION OF PLATE 7

FIGS. 1-3—*Globorotalia palmarealensis* Nuttall, n. sp., × 70; fig. 1, dorsal view; fig. 2, ventral view; fig. 3, apertural view.
4, 6—*Anomalina mecatepecensis* Nuttall, n. sp., × 25; fig. 4, dorsal view; fig. 6, ventral view.
5, 8—*Lepidocyclina asterodisca* Nuttall, n. sp., × 10.
7—*Planulina mexicana* Cushman, × 25.
9—*Cibicides trinitatensis* (Nuttall), × 25.
10, 11—*Cibicides americana* (Cushman), × 60; fig. 10, dorsal view; fig. 11, ventral view.

Nuttall—Oligocene Foraminifera from Mexico

from near the periphery along the inner junction of the last chamber, extending dorsally only the length of the last chamber or for several chambers. Average diameter 0.7 mm.

This species in general appearance resembles *Cibicides filisolaensis* Nuttall[42] found in the Lower Miocene and Upper Oligocene of Southern Mexico.

ANOMALINA ALAZANENSIS Nuttall, n. sp.
Plate 8, figures 5-7

Test plano-convex, dorsal surface nearly flat, ventral surface convex, periphery rounded. Both sides show two whorls, the first whorl being small. Sutures gently curved, thick, limbate slightly raised. Fifteen to seventeen chambers in the last whorl, the chamber surface being coarsely perforate. Aperture narrow, crossing the periphery and extending on the dorsal surface along the inner margin of the last whorl for as much as one-half of a convolution. Diameter 0.7 mm., thickness about 0.15 mm.

This species differs from *A. ammonoides* (Reuss) Brady[43] in having one surface flattened. It resembles *A. mantaensis* Galloway and Morrey,[44] which however has much wider whorls, a sharper periphery and a ventral boss in the umbilicus.

Genus PLANULINA d'Orbigny

PLANULINA WUELLERSTORFI (Schwager)
Plate 4, figures 14, 15

Anomalina wuellerstorfi SCHWAGER, *1866*, Novara Exped., Geol. Theil., p. 258, pl. 7, figs. 105, 107.

Truncatulina wuellerstorfi (Schwager) NUTTALL, *1928*, Quart. Jour. Geol. Soc., vol. 84, p. 98, pl. 7, fig. 12 and references.

Cibicides wuellerstorfi (Schwager) GALLOWAY AND MORREY, *1929*, Bull. Am. Pal., vol. 15, no. 55, p. 31, pl. 4, fig. 11.

Planulina wuellerstorfi (Schwager) CUSHMAN, *1929*, Contr. Cushman. Lab. Foram. Research, vol. 5, p. 102, pl. 15, figs. 1, 2.

The specimens assigned to this species are mostly compressed with a sharp border. In Mexico this form is frequent in the Oligocene and Upper Eocene, while elsewhere in America it has been recorded as ranging from Miocene to Eocene.

PLANULINA MEXICANA Cushman
Plate 7, figure 7

Planulina mexicana CUSHMAN, *1927*, Contr. Cushman Lab. Foram. Research, vol. 3, p. 113, pl. 23, figs. 5 a, b.

This well-defined species is frequent in the Alazan.

PLANULINA ALAZANENSIS Nuttall, n. sp.
Plate 8, figures 4, 8, 9,

Test compressed, slightly more elevated on the dorsal than on the ventral surface. Dorsally with two coils visible, the one at the center small and much obscured by secondary shell growth; the second coil rapidly increasing in width, the chambers being much longer than broad. Ventral surface with a central small circular boss of clear shell substance and the last coil only visible with eleven or twelve chambers. Border narrow. Sutures on both surfaces fairly narrow, limbate, gently curved, depressed or very slightly raised. Chamber surface coarsely perforate. Aperture arched, at the base of the last chamber, extending over the periphery and a short distance down the ventral surface. Diameter 0.6 mm.,

[42] Nuttall, 1928, *Jour. Pal.*, vol. 2, p. 373, pl. 50, figs. 3-5.
[43] Brady, 1884, *Rep.* Challenger, p. 672, pl. 94, figs. 2, 3.
[44] Galloway and Morrey, 1929, *Bull. Am. Pal.*, vol. 15, no. 55, p. 28, pl. 4, fig. 5.

thickness about 0.15 mm. greatest at the center.

This species has been compared with specimens of *P. cocoaensis*,[45] which appears to be the nearest related species. The latter only shows one coil on the dorsal surface, has more curved sutures and a more prominent and better defined boss on the ventral surface. The aperture is also different.

Genus CIBICIDES Montfort

CIBICIDES AMERICANA (Cushman)
Plate 7, figures 10, 11

Truncatulina americana CUSHMAN, *1918*, U. S. Geol. Survey, Bull. 676, p. 63, pl. 20, figs. 2, 3; pl. 21, fig. 1.
Cibicides americana (Cushman) CUSHMAN, *1930*, Florida State Geol. Survey, Bull. 4, p. 61, pl. 12, figs. 5 a-c.—COLE AND GILLISPIE, *1930*, Bull. Am. Pal., vol. 15, no. 57 B, p. 14, pl. 4, fig. 4.

The forms assigned to this species are plano-convex, the dorsal side nearly flat, the ventral convex and the border sharp. The sutures are gently curved and slightly limbate, there being seven or eight chambers in the last whorl. This species is recorded from the Miocene and Oligocene of the Coastal Plain of the United States, and Cole considers that the two forms described under this name are the same species.[46]

CIBICIDES AKNERIANA (d'Orbigny)
Plate 9, figures 1-3

Rotalina akneriana D'ORBIGNY, *1846*, Foram. Foss. Vienne, p. 156, pl. 8, figs. 13-15.

Test nearly plano-convex, rotaliform, dorsal surface flattened, ventral surface convex. Dorsally with the earlier whorls small and obscured by secondary growth of shell substance at the center, the last whorl wide with raised thick limbate sutures, chambers slightly inflated, coarsely perforate, about eleven in the last whorl. Periphery subacute, lobate. Ventral surface generally with a small central umbilical boss of clear shell substance, sutures depressed, chamber surface well elevated, coarsely perforate. Aperture an arched slit over the periphery. Average diameter 0.5 mm.

CIBICIDES CUSHMANI Nuttall

Cibicides cushmani NUTTALL, *1930*, Jour. Pal., vol. 4, p. 291, pl. 25, figs. 3, 5, 6.

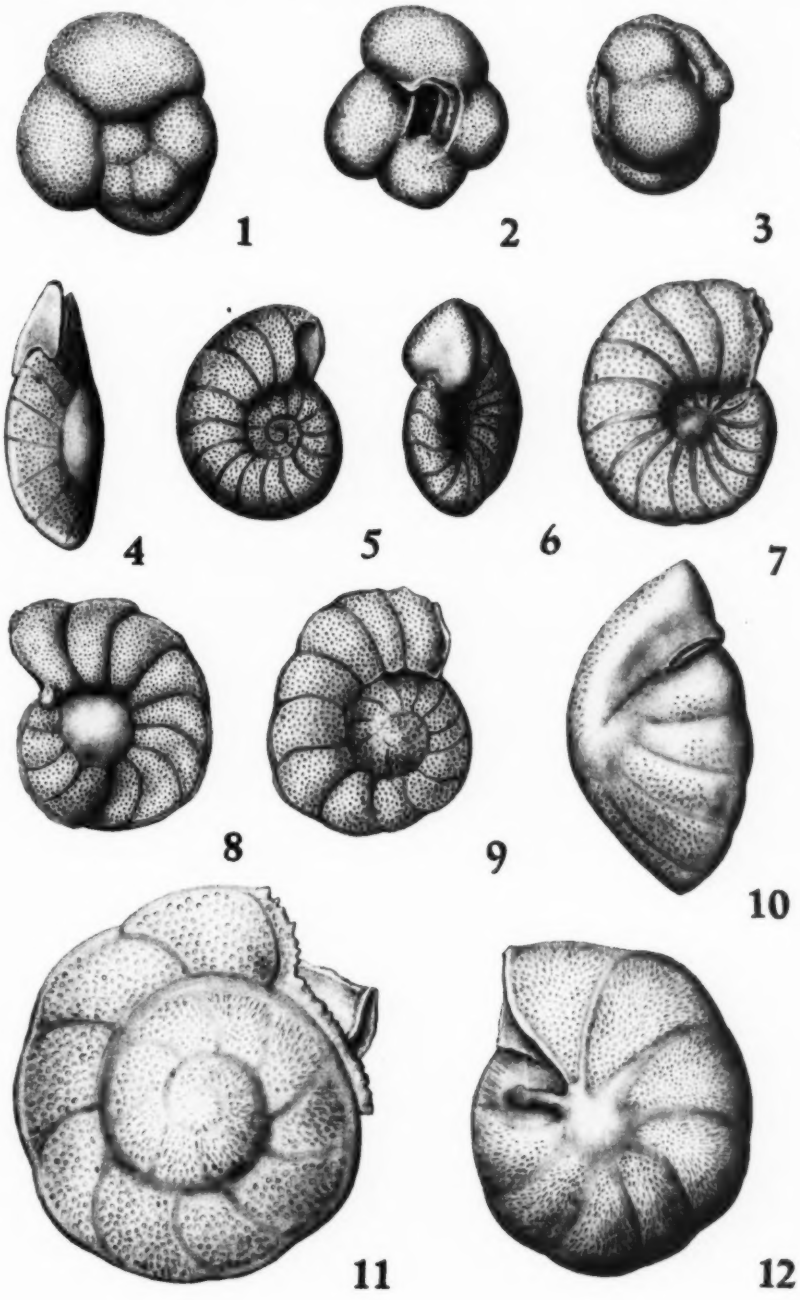
This species was described by the writer from the Aragon and ranges up into the Lower Oligocene.

[45] Cushman, 1928, *Contr. Cushman Lab. Foram. Research*, vol. 4, p. 76, pl. 10, fig. 1.

[46] Reference given above to Cushman 1918; also Cushman, 1918, *U. S. Nat. Mus.*, Bull. 103, p. 68, pl. 23, fig. 2.

EXPLANATION OF PLATE 8

FIGS. 1-3—*Globigerina* cf. *apertura* Cushman, × 50; fig. 1, dorsal view; fig. 2, ventral view; fig. 3, side view.
4, 8, 9—*Planulina alazanensis* Nuttall, n. sp., × 60; fig. 4, apertural view; fig. 8, ventral view; fig. 9, dorsal view.
5, 7—*Anomalina alazanensis* Nuttall, n. sp., × 60; fig. 5, dorsal view; fig. 6, apertural view; fig. 7, ventral view.
10-12—*Cibicides perlucida* Nuttall, n. sp., × 60; fig. 10, apertural view; fig. 11, dorsal view; fig. 12, ventral view.



Nuttall—Oligocene Foraminifera from Mexico

CIBICIDES MEXICANA Nuttall, n. sp.
Plate 9, figures 7-9

Test plano-convex, dorsal side flattened or even slightly concave, ventral side very convex, periphery subacute, about ten chambers in the last whorl. On the dorsal side the chambers are rather indistinct except the last quadrant, the earlier whorls being more or less obscured by secondary development of translucent shell substance, through which the earlier whorls, especially the spiral line between the coils, can usually be seen. Ventrally the chambers are distinct, sutures somewhat limbate, thickened and raised. Wall rather coarsely perforate. Aperture an elongate slit running from the periphery towards the umbilicus along the ventral face of the last formed chamber. Average diameter 0.8 mm., height 0.4 mm.

This species resembles *Cibicides akneriana* (d'Orbigny) from which it is distinguished by its greater thickness and size, also more plano-convex shape. *Rotalina conoidea* Czjzek[47] is more loosely coiled dorsally and in shape more convex.

CIBICIDES PERLUCIDA Nuttall, n. sp.
Plate 8, figures 10-12

Test biconvex, rotaliform; dorsal surface slightly elevated, ventral surface strongly convex, periphery acute. Dorsally two whorls visible, the spiral line thick and distinct, sutures curved narrow, nearly flush with the chamber surface. The wall forming the spiral line and the sutures are of a darker translucent compact texture to the chambers, which are fairly coarsely perforate. About nine chambers in the last whorl. Ventral surface with a large central umbo of clear shell substance, sutures thick, slightly depressed, very gently curved. Aperture a straight narrow slit at the base of the last chamber extending from the periphery for about half the distance to the umbilicus. Average diameter 1 mm.

This species resembles *Rotalina dutemplei* d'Orbigny[48] from which it is distinguished by having a boss at the ventral umbilicus and a more elevated dorsal surface. *Truncatulina dutemplei* of Hantken[49] and *Pseudotruncatulina dutemplei* of Andreae[50] have many more chambers than in our specimens.

CIBICIDES TRINITATENSIS (Nuttall)
Plate 7, figure 9

Truncatulina trinitatensis NUTTALL, *1928*, Quart. Jour. Geol. Soc., vol. 84, p. 97, pl. 7, figs. 3, 5, 6.

The specimens differ only from this species in the boss on the ventral surface being generally smaller.

CIBICIDES TUXPAMENSIS Cole

Cibicides tuxpamensis COLE, *1928*, Bull. Am. Pal., vol. 14, no. 53, p. 19, pl. 1, figs. 2, 3; pl. 3, figs. 5, 6.—NUTTALL, *1930*, Jour. Pal., vol. 4, p. 291, pl. 25, figs. 2, 4.

This species, which has been figured from the Aragon and Chapapote, is also present in the Lower Oligocene. It is readily distinguished by its large size, slightly elevated dorsal surface

[47] Czjzek, 1848, *Haidinger's Nat. Abh.*, vol. 2, p. 145, pl. 13, figs. 4-6.

[48] d'Orbigny, 1846, *Foram. Foss. Vienne*, p. 157, pl. 8, figs. 19-21.

[49] Hantken, 1875 (1876), *Magyar kir. földt. int. évkön.*, vol. 4, p. 61, pl. 8, fig. 5.

[50] Andreae, 1884, *Abh. Geol. Spec. Karte von Elsass.-Lothr.*, vol. 2, p. 213, pl. 8, fig. 10.

and coarse perforations. The periphery is usually rounded, rarely with a subacute edge.

CIBICIDES UNGERIANA (d'Orbigny)
Plate 9, figures 4, 6

Rotalina ungeriana D'ORBIGNY, *1846*, Foram. Foss. Vienne, p. 157, pl. 8, figs. 16-18.

Test rotaliform, dorsal surface flat or slightly convex, ventral surface convex. Dorsally with three visible whorls, the first two small and the last well developed. Sutures gently curved, slightly depressed. Chambers coarsely perforate, about eleven in the last whorl. Ventral surface with a small central boss of clear shell substance, sutures depressed, curved, sometimes with a slight sinuosity towards the border. Periphery narrow, slightly lobate with a narrow border of clear shell substance. Aperture small, an arched opening over the periphery, sometimes extended on the dorsal surface along the inner edge of the last chamber. Average diameter 0.5 mm.

The specimens have been identified by comparison with material from Baden, Austria and appear indistinguishable from topotypes. D'Orbigny's original figure is somewhat conventionalized.

Genus LEPIDOCYCLINA Gümbel

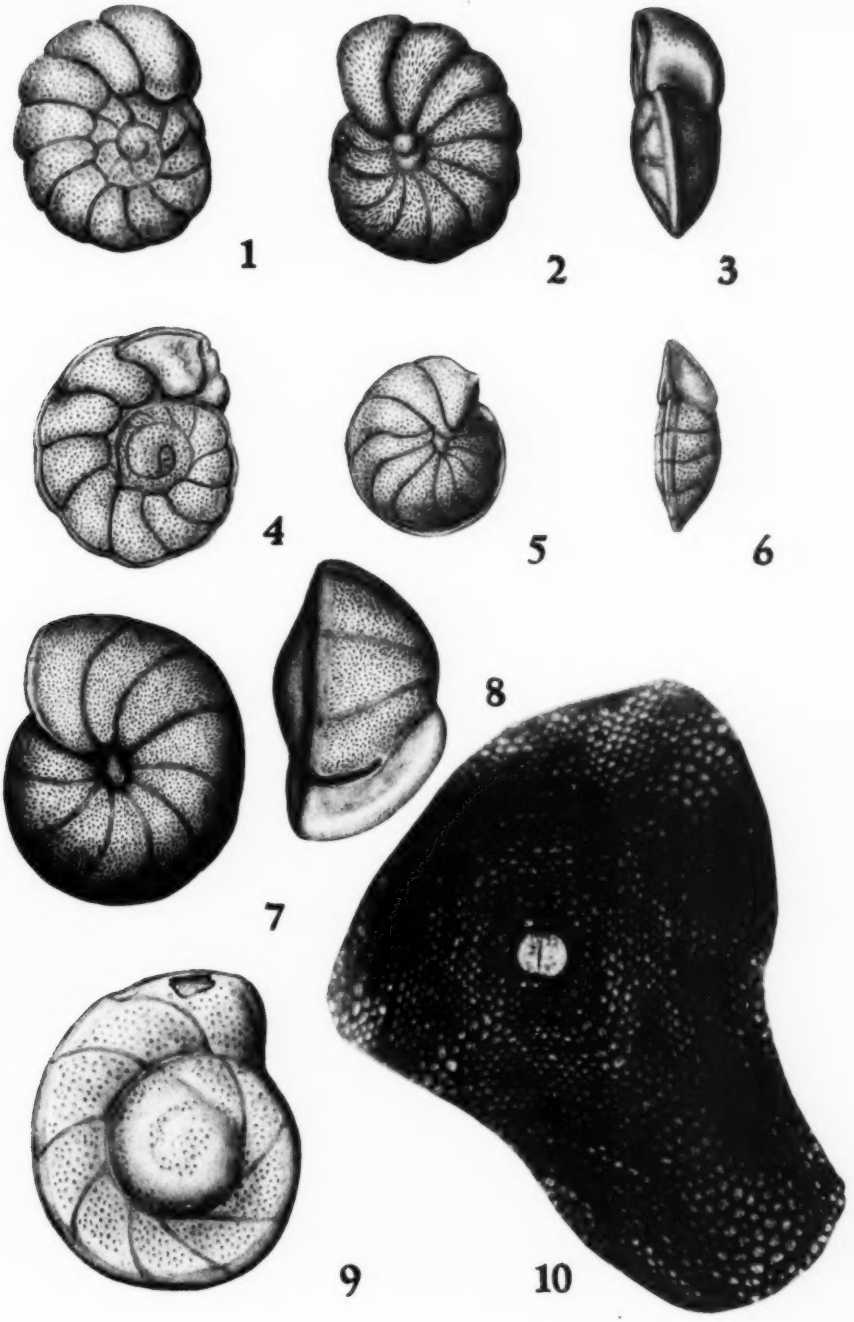
Numerous species of this genus occur, particularly in the Lower Alazan of the region south of the Tuxpam River, where near-shore facies is present in certain areas. In this region the base of the Oligocene is characterized by the presence of *Lepidocyclina favosa* Cushman and *L. mantelli* (Morton). Dr. T. W. Vaughan is preparing a publication on Mexican *Lepidocyclina* collected by himself and geologists of the Eagle Oil Company. With the exception of the following peculiar and rare form, the witer has, therefore, omitted descriptions of the larger foraminifera.

LEPIDOCYCLINA (LEPIDOCYCLINA) ASTERODISCA Nuttall, n. sp.
Plate 8, figures 5, 8; Plate 9, figure 10

Test stellate with four elevated radiate arms, the portion between filled with shell growth to a variable degree. Surface covered with coarse raised papillae, which attain a diameter of 0.1 mm. From these papillae, which constitute the termination of internal pillars, about five narrow septa radiate to adjoining pillars. The diameter of the test is 3.5-5.0 mm. and thickness about 1 mm. An equatorial section shows the

EXPLANATION OF PLATE 9

FIGS. 1-3—*Cibicides akneriana* (d'Orbigny), × 60; fig. 1, dorsal view; fig. 2, ventral view; fig. 3, apertural view.
4-6—*Cibicides ungeriana* (d'Orbigny), × 60; fig. 4, dorsal view; fig. 5, ventral view; fig. 6, apertural view.
7-9—*Cibicides mexicana* Nuttall, n. sp., × 50; fig. 7, ventral view; fig. 8, apertural view; fig. 9, dorsal view.
10—*Lepidocyclina asterodisca* Nuttall, n. sp., × 20; Equatorial section.



Nuttall—Oligocene Foraminifera from Mexico

nucleoconch to consist of two subequal chambers, separated by a straight median septum. The length of the nucleoconch is 0.3 to 0.45 mm. and the width 0.25 to 0.35 mm. The equatorial chambers are hexagonal, except some near the center which are ogival. A vertical section shows the height of the nucleoconch to be 0.4 mm. The equatorial layer increases in thickness towards the periphery, where it attains 0.17 mm. The lateral chambers are about twice as long as high and at the center of the test are about seven in number.

This species is of particular interest because of its radiate form, in this respect resembling the stellate forms of *Discocyclina.* A form showing a similar tendency is *L.waylandvaughani* Cole from the Mexican Upper Oligocene, while a species found in the East Indies with six to nine rays is *Nephrolepidina martini* Schlumberger.

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REVISION OF THE OSTRACODE FAMILY THLIPSURIDAE, WITH DESCRIPTIONS OF NEW SPECIES FROM THE LOWER DEVONIAN OF PENNSYLVANIA

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ABSTRACT

The genus *Thlipsura* Jones and Holl is redescribed and restricted; *Craterellina* Ulrich and Bassler is abandoned, its genotype redescribed and placed in *Thlipsura;* the new genus *Thlipsurella* is proposed, with *T. ellipsoclefta* F. M. Swartz n. sp. as the genotype; a large number of species formerly included in *Thlipsura* are placed in *Thlipsurella,* together with a number of new species, and two species that have been placed in *Craterellina. Octonaria* Jones is redescribed, and it is proposed to remove several species, and to group most of the others in four sections, while the generic relations of several other species are considered obscure.

Beside redescription of *Thlipsura robusta* (Ulrich and Bassler) and *Thlipsurella oblonga* (Ulrich and Bassler), the following new Shriver chert species are described and figured: *Thlipsura confluens, T. robusta* var. *tricornis, Thlipsurella ellipsoclefta, T. secoclefta, T. curtinensis, T. orthoclefta, T. crateriformis, Octonaria deltisulcata, O. dorsosulcata.* One new species, *O. altoonensis,* is described from the Keyser limestone.

INTRODUCTION

This paper proposes revisions of certain parts of the ostracode family *Thlipsuridae,* describes nine new species of the family from the Shriver chert of the Lower Devonian Oriskany group of central Pennsylvania, and redescribes two other species. An additional new species is described from the Keyser limestone of the Lower Devonian Helderberg group at Altoona, Pennsylvania. The revisions suggested for several genera are a result of study of the proper generic positions of the *Thlipsuridae* of the Shriver, together with the consequent review of previously described species.

The material on which descriptions of the Shriver chert species are based, was obtained from four localities in central Pennsylvania: (1) along the road to Frankstown, about one-half mile east of Hollidaysburg; (2) along the old road to Burnham, at the bridge crossing Kishacoquilis Creek in the northern outskirts of Lewistown; (3) just north of the highway, one-half mile southwest of Curtin crossroad about three miles north of Bellefonte; and (4) near the east bank of Pine Creek, south of the highway from Avis to Jersey Shore. Several of the ostracodes were first discovered in a slab of the Shriver chert found in the collections at the Pennsylvania State

College, and labelled "Collected by J. B. Payne, near Altoona, Pennsylvania." Almost all of the ostracode specimens are exterior or interior molds, found in weathered specimens of the rock. The beds in which the ostracodes are most profuse are composed of very finely divided silica, cemented by lime, and the removal of the lime by weathering leaves impressions of the carapaces that preserve the ornamentation in remarkable detail. The illustrations here used for the Shriver chert species are photographs of gutta percha impressions from the natural external molds.

STRATIGRAPHIC RELATIONS OF THE SHRIVER CHERT

The type locality of the Shriver chert is Shriver Ridge, near Cumberland, in western Maryland.[1] At that place the Shriver is a dark, highly siliceous shale, containing much black, very impure, bedded chert. It is about 130 feet thick, and lies between the New Scotland limestone of the Helderberg group, below, and the Ridgeley sandstone of the Oriskany group, above. The *Spirifer arenosus-Hipparionyx proximus* fauna of the typical Oriskany of New York is found in the Ridgeley sandstone, and not in the Shriver chert. The fauna of the Shriver is an impoverished one.

The Shriver maintains in central Pennsylvania the same stratigraphic relations as in western Maryland, and its thickness, lithology, and fauna are very similar. In central Pennsylvania the chert-like material is very impure and somewhat calcareous. Bedded dark chert with true cherty luster becomes predominant in the Shriver east of the fossil localities mentioned above. In central Pennsylvania, at least, the fossils are not uniformly distributed throughout the formation. The lower beds, about 50 feet thick, are very nearly barren, although rare specimens of *Anoplotheca flabellites* are found. The beds about 50 to 85 feet above the base of the formation contain a considerable abundance of ostracodes, *Tentaculites elongatus,* and several brachiopods. The most important of the latter is *Metaplasia ? plicata* Weller, a species not hitherto reported from the Shriver, although it is rather abundant and persistent in this part of the Shriver in central Pennsylvania. The uppermost 30 or 40 feet of beds are somewhat more limy than the rest, and contain a fairly large fauna of brachiopods, trilobites, and ostracodes. Work has not yet established the ranges of all of the observed ostracodes but so far as possible the limits of their occurrences will be given.

[1] Swartz, C. K., and others, *Md. Geol. Survey,* Lower Devonian, p. 91, 1913.

ACKNOWLEDGMENTS

The writer acknowledges with pleasure the cordial coöperation of Dr. R. S. Bassler, who permitted and facilitated examination of type material at the U. S. National Museum, and made suggestions concerning the photographs. He is also greatly indebted to Dr. Charles K. Swartz for suggestions, and for reading the parts of the manuscript dealing with generic revisions.

SYSTEMATIC DESCRIPTIONS

Family THLIPSURIDAE Jones

Genus THLIPSURA Jones and Holl, emend. F. M. Swartz

Thlipsura JONES AND HOLL (part), *1869,* Ann. Mag. Nat. Hist., (4) vol. 3, p. 213.—ULRICH AND BASSLER (part), *1921,* Md. Geol. Survey, Silurian, p. 317, fig. 23:6.—ROTH (part), *1929,* Jour. Pal., vol. 3, pp. 352-358.

Craterellina ULRICH AND BASSLER (part), *1913,* Md. Geol. Survey, Lower Devonian, pp. 539, 540; *1921,* Md. Geol. Survey, Silurian, p. 318.

Not *Thlipsura* JONES, *1886,* Ann. Mag. Nat. Hist., (5) vol. 19, pp. 402-404; *1887, Idem.,* (6) vol. 1, p. 404.—KRAUSE, *1891,* Zeits. deutsch. Geol. Gesell., vol. 43, pp. 508, 509.—ULRICH AND BASSLER, *1913,* Md. Geol. Survey, Lower Devonian, p. 536.—KUMMEROW, *1923,* Jb. Preuss. Geol. Landesanstalt, p. 433.

Characters of the genus. Jones and Holl's original description of *Thlipsura* is as follows: "A cytheroid carapace, indented on its anterior third by a variable and evanescent pit, and posteriorly by a deeper and permanent depression, characterizes the Silurian species which we have to place by themselves in this new generic group." A footnote explains that the genus was named "in allusion to the compression of the posterior extremity." Three species, *Thlipsura corpulenta, T. v-scripta,* and *T. tuberosa* were described and placed in the genus. Of these, *T. corpulenta* was the first described, and, although it was not specifically cited as the genotype, was apparently so considered by Jones and Holl. According to rules of zoölogical nomenclature this species is the genotype and it was so regarded by Ulrich and Bassler. Also, of the three original species, it is the one in which the described generic characters are best shown, although with the orientation used by Ulrich and Bassler, Roth, and the present writer, the "compressed" end of the carapace is considered anterior and not posterior.

Based upon *T. corpulenta* and its closest known ally, *T. furca* Roth, the genus *Thlipsura* may be more fully described as follows: Carapace of moderate size, about 1.5 mm. or less in length; thick, subelliptical to suboblong in dorsal view, the greatest thickness toward the front; subreniform to subovate in side view, the dorsal margin strongly convex, ventral margin nearly straight, greatest height in front of the middle, greatest length nearer the ventral than the dorsal margin; valves slightly unequal, the right overlapping a little on the left, at least along the free margins. Surface of valves strongly, more or less evenly, convex, except that the region bordering the anterior margin is abruptly depressed to form a large projecting shelf-like or lip-like area. The sunken area is open to the front, but is sharply defined behind by a step-like rise, except where one or two furrows or re-entrants extend backward from it for some distance. Varieties of *T. corpulenta* are reported by Jones and Holl to have a small additional depression a little behind the middle of the valve. Genotype, *T. corpulenta* Jones and Holl, Woolhope shales, Silurian of England.

Additions and subtractions of species. Considering the large anterior sunken area as a diagnostic feature, the genus *Thlipsura* is here restricted

to include only the following described species:

Thlipsura corpulenta JONES AND HOLL, Silurian, England.
Thlipsura furca ROTH, Haragan marl, Lower Devonian, Oklahoma.
Thlipsura primitiva ROTH, Haragan marl, Lower Devonian, Oklahoma.
Thlipsura confluens F. M. SWARTZ, n. sp., Shriver chert, Lower Devonian, Pa., Md.
Craterellina robusta ULRICH AND BASSLER, Shriver chert, Lower Devonian, Pa., Md.
Thlipsura robusta var. tricornis F. M. SWARTZ, n. var., Shriver chert, Lower Devonian, Pa., Md.

The other species that have been placed in *Thlipsura,* with the exception of *T. triloba* Kummerow, are combined in this paper with several new species, and two species that have previously been placed in *Craterellina,* in the new genus *Thlipsurella.* These species are listed under the description of that genus.

The anterior sunken area of *Thlipsura furca* is somewhat larger and better defined than in *T. corpulenta;* also *T. furca* has two well defined short longitudinal furrows extending backward from the sunken area, instead of the single poorly defined furrow of *T. corpulenta. T. furca* is particularly interesting in that it connects *T. corpulenta* with *T. confluens,* in which the upper of the two furrows is complicated by branches, and with *T. robusta* (Ulrich and Bassler) and *T. robusta* var. *tricornis* in which the two furrows are shortened and expanded to form broadly rounded re-entrants in the posterior margin of the sunken area, separated by a sharp median spur. The other species here included in *Thlipsura, T. primitiva* Roth, has no trace of the longitudinal sulci, and the posterior margin of the sunken area is straight and vertical.

Abandonment of Craterellina *Ulrich and Bassler. T. robusta* is a Shriver species that was originally described by Ulrich and Bassler as having a strongly convex surface, marked anteriorly by a large crateriform depression that was said to have a strongly elevated rim entirely surrounding it, in front as well as elsewhere. It was accordingly made the type of a new genus, *Craterellina,* and with it was placed another species from the Shriver chert named *Craterellina oblonga. C. oblonga* was said to have a similar large anterior crateriform depression, with a single large node rising from its floor, whereas there are two nodes on the floor of the sunken area of *T. robusta.* The excellent material obtained from the Shriver of central Pennsylvania shows clearly that both of these species have been misinterpreted, while Roth's discovery of *T. furca* helps to clarify the generic relations of *T. robusta.* The Pennsylvania material shows that the sunken area of *T. robusta* is not bounded anteriorly by a rim, but is open to the front, and comparison with *T. furca* indicates that the two broad re-entrants of the posterior margin of the sunken area represent the two longitudinal furrows of that species. On the other hand, the supposed crateriform depression of *C. oblonga* is actually a comparatively large but narrow C-shaped cleft, surrounding a large tabular area that connects with the general surface of the valve by a narrow isthmus. This cleft

is bounded anteriorly by a sharply elevated rim. Consequently *C. oblonga* and *T. robusta* are very different forms, by no means intimately related. The only known close relative of *T. robusta* is *T. furca.* In view of these observations it seems well to abandon the genus *Craterellina,* and to include its genotype with *T. furca* in the genus *Thlipsura. C. oblonga,* on the other hand, is here placed in one section of the new genus *Thlipsurella.*

Removal of Thlipsura triloba. *Thlipsura triloba* Kummerow is a species of very doubtful affinities. As figured by Kummerow it has a short straight dorsal margin, is equal-ended, the greatest length is nearer the ventral than the dorsal margin, and there are two broad sulci extending dorsally from the ventral margin. As figured, this species certainly does not belong in *Thlipsura.*

THLIPSURA CONFLUENS F. M. Swartz, n. sp

Plate 10, figures 3 a-i

Carapace thick, subovate in dorsal view, greatest thickness about

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EXPLANATION OF PLATE 10

FIGS. 1—*Thlipsura corpulenta* Jones and Holl, the genotype, left valve, × 20. Silurian Woolhope limestone, England. After Ulrich and Bassler.

2*a, b*—*Thlipsura furca* Roth. *a,* Left valve, × 30; *b,* dorsal view of carapace, × 30. Lower Devonian, Haragan marl, Oklahoma. After Roth.

3*a-i*—*Thlipsura confluens* F. M. Swartz, n. sp. *a,* Right valve, × 15; *b,* dorsal view of carapace, × 15, (note offset from hinge to anterior free edge); *c, d, e,* side, ventral, and anterior views of right valve, × 15; *f,* left valve, × 15; *g, h,* side and anterior views of left valve, × 15, with part of overlapping anterior edge of right valve, and with anterior vertical ridge extended dorsally so as to cut off the upper cleft from the anterior depressed area; *i,* left valve, × 15, *a, c, d, e, g, h,* Hollidaysburg, Pennsylvania, 90-110 ft. above base of Shriver chert; *b, f,* Lewiston, Pennsylvania, 67 feet above base of Shriver chert; *i,* Curtin, Pennsylvania, *Metaplasia plicata* zone of middle part of the Shriver chert.

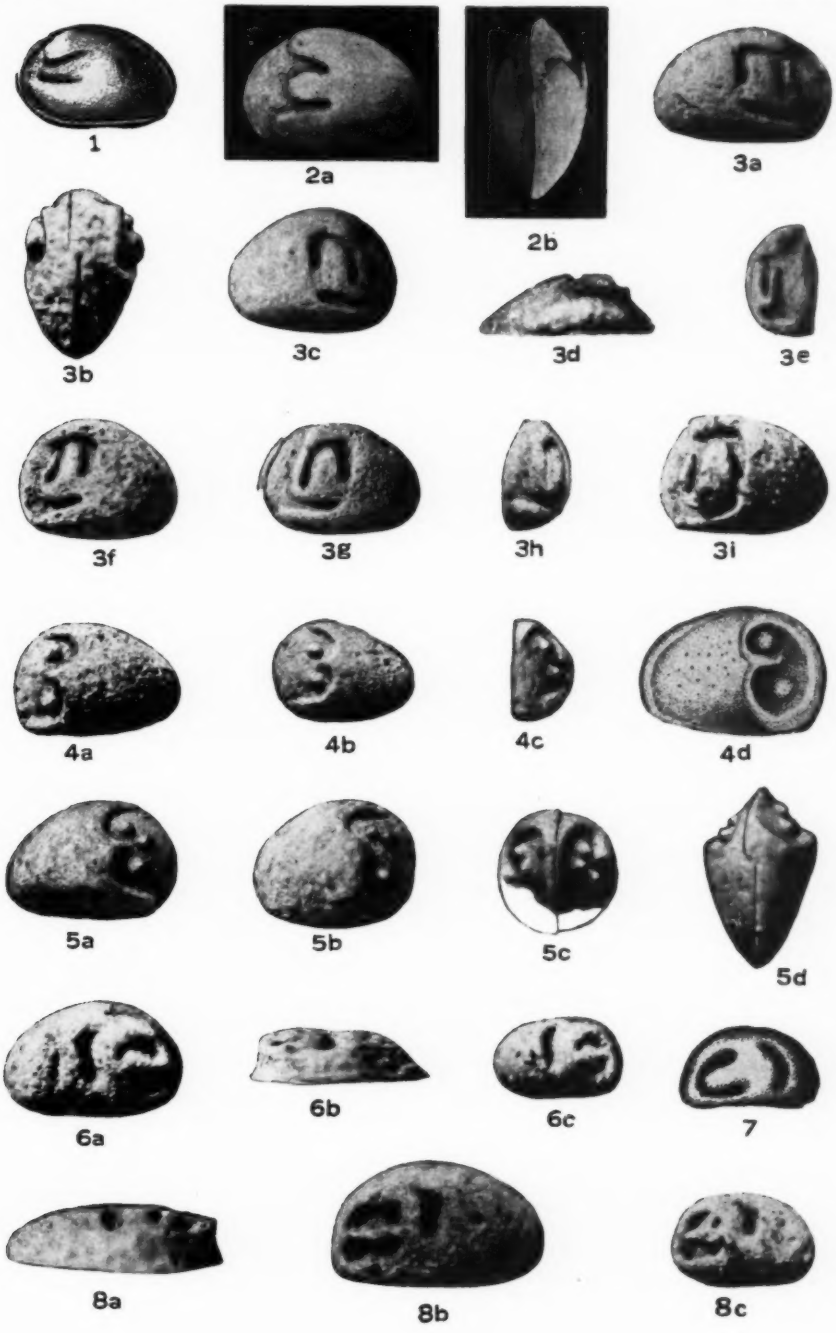
4*a-d*—*Thlipsura robusta* (Ulrich and Bassler). *a,* Left valve, × 15, Curtin, Pennsylvania, *Metaplasia plicata* zone of middle part of Shiver chert; *b, c,* side and anterior views of left valve, × 15, Lewiston, Pennsylvania, 67 ft. above base of Shriver chert; *d,* the original figure for this species, a right valve, × 20, Shriver chert of Maryland, showing the supposed strong rim surrounding the "crater."

5*a-d*—*Thlipsura robusta* var. *tricornis* F. M. Swartz, n. var. *a,* Right valve, × 15, found in a slab collected near Altoona, Pennsylvania, by J. B. Payne; *b,* right valve, × 15, Hollidaysburg, Pennsylvania, 90-110 ft. above base of Shriver chert; *c, d,* anterior and dorsal views of incomplete carapace, same locality and horizon.

6*a-c*—*Thlipsurella ellipsoclefta* F. M. Swartz, n. g. and n. sp. *a, b,* Side and dorsal views of right valve, × 29; *c,* side view of a small right valve, × 29; both from Curtin, Pennsylvania, *Metaplasia plicata* zone of middle part of the Shriver chert.

7—*Thlipsurella v-scripta* (Jones and Holl). Left valve, × 20. Silurian, Island of Gotland. After Ulrich and Bassler, apparently from Krause. Given as *Thlipsura v-scripta* var. *discreta* Jones by Krause and Ulrich and Bassler, although the anterior clefts are confluent, and not separated. As figured by Jones and Holl the English specimens are subovate and not subreniform.

8*a-c*—*Thlipsurella secoclefta* F. M. Swartz, n. sp. *a, b.* Dorsal and side views of a left valve, × 29, Lewiston, Pennsylvania, 105-110 ft. above base of Shriver chert; *c,* smaller left valve, × 29, Curtin, Pennsylvania, *Metaplasia plicata* zone of middle part of the Shriver chert.



Swartz—Devonian ostracodes, Thlipsuridae

one-third of the length from the front; subreniform to subovate in side view, the dorsal margin very convex, the ventral margin nearly straight, anterior margin broadly curved, higher and blunter than the more sharply curved posterior margin; greatest height distinctly in front of the middle, greatest length nearer the ventral than to the dorsal margin; right valve a little larger than the left, overlapping the left along the free margins. The offset of the free margin in front of the hinge is shown in Pl. 10, fig. 3b. The material does not show whether there is a similar offset at the rear end of the hinge.

Surface of valve strongly and rather regularly convex, sloping somewhat more steeply to the ventral margin than elsewhere; suddenly sunken at the front to form a fairly large shelf-like area that is open to the front, well defined behind, and depressed below the general level of the surface, but still convex; this area is sublunate in shape, borders the entire anterior margin, and extends backward about one-sixth or one-seventh the length of the valve. About one-fifth of the distance above the ventral margin, a simple rather narrow deep cleft, nearly horizontal but rising a little to the rear, opens from the anterior depressed area and extends backward a little less than to the vertical mid-line of the valve. A second cleft opens from the depressed area about one-fifth of the distance below the dorsal margin, and extends backward parallel to the lower cleft to about the vertical mid-line of the valve, where it turns sharply downward, and extends nearly to the horizontal mid-line. Near the junction with the depressed area another branch extends downward to a little below the horizontal mid-line, closely paralleling the posterior margin of the depressed area. The upper cleft with its two subvertical branches suggests a square cornered overturned U, or slightly distorted Greek letter Π. The area enclosed by the clefts is broad, flat-topped, and rises to the level of the general surface of the valve, but the narrow ridge separating the anterior vertical branch of the upper cleft from the anterior depressed area is distinctly lower. This ridge is confluent below with the flat-topped area enclosed by the clefts, and rarely is extended dorsally across the mouth of the upper cleft, so as to cut off partially that cleft from the anterior sunken area. The strong ridges extending forward from the general surface of the valve below the lower cleft and above the upper cleft, terminate abruptly at the front, defining the lower and upper parts of the anterior sunken area. Well preserved specimens show that the floor of the sunken area is studded with eight or ten small, low, rounded nodes. Surface apparently without other ornament.

A representative right valve measures length 1.58 mm.; height 1.11 mm.; convexity or thickness 0.53 mm.

Thlipsura confluens is closely related to *T. furca* Roth, of the Lower Devonian Haragan marl of Oklahoma; but in that species the upper cleft is simple. The anterior sunken area, open to the front, well defined behind,

is suggestive of *Thlipsura robusta* and its variety *tricornis.*

Occurrence. One of the most abundant ostracodes of the upper half of the Shriver chert of central Pennsylvania; abundant 90 to 110 feet, common 110 to 117 feet above the base of the Shriver at Hollidaysburg, Pennsylvania; common 60 to 87 feet above base of the Shriver at Lewistown, Pennsylvania; abundant in the *Metaplasia plicata* zone of the middle part of the Shriver at Curtin, Pennsylvania.

THLIPSURA ROBUSTA (Ulrich and Bassler)
Plate 10, figures 4 a-d

Craterellina robusca ULRICH AND BASSLER, *1913,* Md. Geol. Survey, Lower Devonian, p. 549, pl. 98, fig. 21.

Carapace longitudinally subreniform to subovate in side view, dorsal margin strongly convex, ventral margin nearly straight, anterior end broadly rounded, turning more abruptly to the ventral than to the dorsal margin, posterior end more sharply rounded; greatest height distinctly in front of the middle, greatest length nearer the ventral than to the dorsal margin. Right valve a little larger than the left, overlapping the left along the free margins. A dorsal view of *T. robusta* var. *tricornis* (Pl. 10, fig. 5d) shows the offset of the free margin in front of the hinge.

Surface of valve strongly and rather regularly convex, sloping more steeply to the ventral margin than elsewhere; abruptly sunken at the front to form a large shelf-like anterior area depressed below the general level of the valve, but still convex; this sunken area borders the entire anterior margin of the valve, and extends about one-fourth of the distance from the anterior to the posterior margin. It is open in front, and sharply defined behind by the sudden rise to the general surface of the valve. In the internal casts this rise is surmounted by a distinct eyebrow-like ridge, but no such ridge is present on the exterior, the ridge on the internal casts apparently being due to the fact that the carapace is a little thinner along the summit of the rise than elsewhere; the region just back of the rise is however the most highly elevated part of the valve. The posterior margin of the sunken area has two broadly rounded re-entrants, separated by a sharp median spur, and bordered dorsally and ventrally by two ridges jutting forward from the general surface of the valve; the ventral ridge terminates very abruptly at the front, while the dorsal one declines somewhat more gradually, but becomes obsolete before reaching the anterior margin, so that it does not close off the front of the anterior sunken area. The floor of the sunken area is convex, and is marked by two rather large rounded nodes, one lying off the upper, and one off the lower re-entrant; these nodes are subject to some variation in size, those of one specimen being almost twice as large in diameter as those of the figured specimens. Surface apparently otherwise smooth.

A large left valve measures length 1.49 mm., height 1.00 mm., convexity or thickness 0.53 mm. The measurements given by Ulrich and Bassler are length 1.25 mm., height 0.9 mm.

The specimens studied by Ulrich

and Bassler were apparently weathered carapaces, and the species was figured and described as having a very strong rim entirely enclosing the anterior sunken area, not only surmounting the rise at the posterior margin of the area, but closing in the front margin as well. This resulted not only in an erroneous conception of the species, but also in an erroneous conception of the genus which was erected with this species as the genotype. As noted elsewhere, the anterior sunken area of *T. robusta* corresponds with the anterior sunken area characteristic of *Thlipsura,* and the two re-entrants probably represent the two simple clefts of such a species as *T. furca* Roth, but shortened and greatly expanded; while the nodes of the area are matched by smaller more numerous ones in *T. confluens.*

Occurrence. Fairly common in the *Metaplasia plicata* zone at Curtin, Pennsylvania; rare in this zone, 67 feet above the base of the Shriver, at Lewistown, Pennsylvania.

THLIPSURA ROBUSTA var. TRICORNIS
F. M. Swartz, n. var.
Plate 10, figures 5 a-d

Outlines and convexity of the carapace as in *T. robusta,* the surface of the valve with the same well defined anterior sunken area, with the two broadly rounded posterior re-entrants separated by a median spur, and with the forward jutting dorsal and ventral ridges terminating in front so that the sunken area is open anteriorly, and is also without a distinct ridge at the summit of the rise defining the posterior margin of the sunken area. The variety *tricornis* differs from *T. robusta* only in that there are three instead of two large nodes studding the floor of the anterior sunken area, the largest of the three lying off the lower re-entrant, two slightly smaller nodes lying off the upper re-entrant.

A representative right valve measures length 1.51 mm., height 1.00 mm., convexity or thickness 0.53 mm.

This variety is very close to *T. robusta.* At present the difference in the number of nodes appears to have some stratigraphic value, as *T. robusta* has so far been found in central Pennsylvania only in the *Metaplasia plicata* zone of the middle part of the Shriver chert, whereas *T. robusta* var. *tricornis* appears here, but continues into the upper part of the Shriver.

Occurrence. Common 90 to 110 feet above the base of the Shriver chert at Hollidaysburg, Pennsylvania, rare 98 feet above the base of the Shriver at Lewistown, rare in *Metaplasia plicata* zone of the middle part of the Shriver at Curtin, Pennsylvania.

Genus THLIPSURELLA F. M. Swartz, new genus

Thlipsura JONES AND HOLL (part), *1869,* Ann. and Mag. Nat. Hist., (4) vol. 3, p. 214.—JONES, *1886,* Ann. and Mag. Nat. Hist., (5) vol. 19, pp. 402-404.—ULRICH AND BASSLER, *1913,* Md. Geol. Survey, Lower Devonian, p. 536; (part), *1921,* Md. Geol. Survey, Silurian, p. 317, fig. 23, 5.—ROTH (part), *1929,* Jour. Pal., vol. 3, pp. 352-358.

Primitia KRAUSE (part), *1877,* Zeits. deutsch. Geol. Gesell., vol. 29, p. 38.

?Thlipsura KRAUSE, *1891,* Zeits. deutsch. Geol. Gesell., vol. 43, pp. 508, 509.

Craterellina ULRICH AND BASSLER (part), *1913,* Md. Geol. Survey, Lower Devonian, p. 540.—ROTH, *1929,* Jour. Pal., vol. 3, p. 362.

Characters of the genus. Restricting the genus *Thlipsura* to those cytheroid species that, like *T. corpulenta,* have the region bordering the anterior margin depressed to form a well defined sunken area, with one or two furrows opening from this area and extending backward for some distance, the majority of the species that have been included in *Thlipsura* must be placed elsewhere. Except for *T. triloba* Kummerow, they are here grouped, along with two species that have been placed in *Craterellina,* and several new species described in this paper, in a new genus for which the name *Thlipsurella* is proposed.

The features characteristic of this genus are as follows: Carapace generally 1 mm. or less in length; moderately thick, tending to be subovate in dorsal view, with greatest thickness in front of the middle; subreniform to subovate in side view, the dorsal margin strongly convex, the ventral margin nearly straight; greatest height in front of the middle, greatest length nearer the ventral than the dorsal margin. Right valve overlaps a little on the left; hingement apparently not well defined. Surface of valve generally most convex in front of the middle; anterior margin marked typically by two sublongitudinal furrows that are closed off in front by a more or less distinct rim, that rises steeply from the anterior margin; typically there is an additional short subvertical furrow about on or a little behind the middle of the valve, and sometimes there is a pit behind this. In a considerable number of the species there is only one anterior furrow, and in these species the submedian nearly vertical furrow is generaly absent, and the posterior region may be marked by one or two pits, or may be devoid of markings. Other ornamentation rare. Genotype *Thlipsurella ellipsoclefta* F. M. Swartz n. sp., Lower Devonian Shriver chert of Pennsylvania. *Thlipsura v-scripta* Jones and Holl might have been designated as the genotype, but it was thought better to use a species that could be studied at first hand.

Proposed sections. It is proposed to place the species here listed in the genus *Thlipsurella,* and to group them in the following sections:

1. Section of *Thlipsurella ellipsoclefta:*
   Thlipsurella ellipsoclefta F. M. Swartz n. sp.[2]
   Thlipsurella secoclefta F. M. Swartz n. sp.[2]
   Thlipsura multipunctata Ulrich and Bassler.[3]
   Thlipsura v-scripta Jones and Holl.[4]
   Thlipsura v-scripta var. *discreta* Jones,[4] considered by Jones equivalent to *Primitia minuta* Krause.[3]
   Thlipsurella curtinensis F. M. Swartz n. sp.[2]
2. Section of *Thlipsurella plicata* (Jones):
   Thlipsura plicata Jones.[3]
   Thlipsura plicata var. *unipunctata* Jones.[3]
   Thlipsura plicata var. *bipunctata* Jones.[3]
   Thlipsura angulata Jones.[3]
   Thlipsura curvistriata Roth.[4]
   Thlipsura muricurva Roth.[4]
   Thlipsura fossata Roth.[4]
   Thlipsura tuberosa Jones and Holl.[4]
3. Section of *Thlipsurella oblonga* (Ulrich and Bassler):

[2] Lower Devonian Shriver chert of Maryland and Pennsylvania.
[3] Middle and Upper Silurian of Europe.
[4] Lower Devonian Haragan marl of Oklahoma.

Craterellina oblonga Ulrich and Bassler.[3]
Craterellina moorei Roth.[4]
Thlipsurella orthoclefta F. M. Swartz n. sp.[3]
Thlipsurella crateriformis F. M. Swartz n. sp.[3]

4. Section of *Thlipsurella parallela* (Roth):
Thlipsura parallela Roth.[4]
Thlipsura striatopunctata Roth.[4]

5. Species of doubtful affinities, provisionally placed in *Thlipsurella:*
Thlipsura simplex Krause.[3]
Thlipsura personata Krause.[3]
Thlipsura tetragona Krause.[3]

The section of *Thlipsurella ellipsoclefta* exhibits the features typical of the genus except that in *T. secoclefta* and *T. multipunctata* each of the two anterior clefts is overdeepened at each end, thus forming a group of four anterior pits. *T. multipunctata* lacks the median subvertical furrow, and is supposed to have two pits paralleling the post-dorsal margin. *T. v-scripta* has the two anterior clefts confluent in front. Inclusion of *T. curtinensis* in this section is questionable, as it is suboblong rather than subreniform in outline, and has a single subvertical anterior cleft instead of the normal two sublongitudinal clefts. Furthermore, the median depression is funnel-shaped, and not like the furrow normal to the section.

The section of *Thlipsurella plicata* differs from that of *T. ellipsoclefta* in that there is a single oblique anterior cleft, apparently representing the upper, or sometimes the lower, of the two sublongitudinal anterior clefts of the typical form. The posterior portion is either unmarked, or has one or two small pits. *T. muricurva* exhibits a peculiar median boss. *T. tuberosa* has a similar median boss, but apparently lacks a distinct anterior furrow.

In the section of *Thlipsurella oblonga,* the outline tends to be suboblong to subovate, rather than strongly subreniform, and the anterior moiety is marked by a single sulcus, with no posterior markings.

Thlipsurella parallela and *T. striatopunctata* have two long sublongitudinal clefts, extending well behind the middle of the valve, and lack other depressions. These species tend to develop a tetragonal outline.

Questionable species. The three remaining species, *Thlipsura simplex* Krause, *T. tetragona* Krause, and *T. personata* Krause, are not sufficiently related to form a section of their own, as they differ very greatly in outline from the side view, and the first is marked by one, the second by two, and the third by three short clefts, of rather irregular disposition. There is some degree of relationship in that the clefts are short and simple. *T. simplex* has been provisionally placed in *Octonaria* by Ulrich and Bassler[5], however, it lacks the marginal flange of that genus, and its small median cleft and subelliptical outline are as far from the markings and outline of *Octonaria* as from those of *Thlipsurella.* Also, the surface of the valve rises sharply from the margin at one end, and declines gradually to the margin at the other, as is typical of *Thlipsurella.* The convexity of the surface is similar in *T. personata. T. tetragona* has a tetragonal

[5] *Md. Geol. Survey,* Lower Devonian, p. 538, 1913.

outline, much like that of *T. paralela,* except that with the orientation given by Krause the convex margin is made ventral and not dorsal, and the greatest length is much nearer the dorsal than the ventral margin. If the orientation given by Krause is incorrect, this species fits better in *Thlipsurella.* Oriented as is *T. parallela,* the convexity of the surface again agrees with that typical of *Thlipsurella.*

THLIPSURELLA ELLIPSOCLEFTA
F. M. Swartz, n. sp.
Plate 10, figures 6 a-c

Carapace moderately thick, subovate, to suboblong in dorsal view, suddenly expanded at the front, the sides then nearly parallel for some distance, gradually tapering in the posterior third, although the posterior end is usually more rounded than is suggested by the figure showing a valve in dorsal view; subreniform in side view, not strongly subovate; dorsal margin strongly convex, ventral margin nearly straight; greatest height a little in front of the middle, greatest length nearer the ventral than the dorsal margin. Character of overlap not observed in the material studied, but most probably the same as in *T. secoclefta,* in which the right valve is slightly the larger, and overlaps a little upon the left, apparently along the entire margin, the hinge not being well defined.

Surface of valve convex, somewhat flattened on top, abruptly elevated at the front, the rise concave and overhanging, descending a little more steeply to the ventral than to the dorsal and posterior margins. Marked just behind the vertical mid-line of the valve by a nearly vertical, deeply impressed cleft that extends from a little below the middle of the valve to about one-fourth the distance below the dorsal margin, where a short shallow extension of the cleft suddenly flares forward. Anteriorly there is a pair of subhorizontal, deep, rather narrow, slightly curved clefts, their concave margins in apposition, forming an ellipse that is incomplete at either end, and resembling the proof-reader's sign to close space. These clefts are closed at the front, ending here as abruptly as at the rear, the surrounding surface forming a continuous rim in front of and above and below them. The slope below the rim is somewhat excavated and concave along the margin of the anterior third of the valve, the furrowing thus produced ending abruptly at each end. The surface is also marked a little behind the submedian vertical cleft by a small, short, rather shallow, vertically elongated depression. This depression is subject to some variation in size and outline. Surface apparently without other ornament.

The large figured right valve measures length 0.82 mm., height 0.49 mm., greatest convexity or thickness about 0.24 mm.

T. ellipsoclefta is very closely related to *T. secoclefta.* It is also related to *T. v-scripta* (Jones and Holl), but in that species the submedian vertical cleft is a little more posterior in position, and more curved, and the two anterior clefts are confluent in front, and more divergent behind. *T.*

v-scripta var. *discreta* (Jones) has the two anterior clefts separated, but they are apparently not distinctly curved, and they are more divergent behind, while the position and curvature of the submedian cleft agrees with that of *T. v-scripta*. The latter species and the variety *discreta* were originally figured with subelliptical and not subreniform outlines. As figured by Krause, specimens of *T. v-scripta* from the Silurian of Gotland have a strongly subreniform outline.

Occurrence. Common in *Metaplasia plicata* zone of the middle part of the Shriver chert at Curtin, Pennsylvania.

THLIPSURELLA SECOCLEFTA F. M. Swartz, n. sp.
Plate 10, figures 8 a-c

Carapace moderately thick, suboblong in dorsal view, suddenly expanded at the front, sides nearly parallel but a little bulging, tapering to the rounded posterior end; subreniform not distinctly subovate in side view, dorsal margin strongly convex, ventral margin nearly straight, anterior margin a trifle higher than the posterior, rising obliquely backward from the sharply curved antero-ventral bend, posterior margin more evenly rounded; greatest height a little in front of the middle, greatest length nearer the ventral than to the dorsal margin. Overlap not very well shown in the material studied, but the right valve overlaps a little on the left, apparently along all the margins, the hinge not well defined.

Surface of valve moderately convex, somewhat flattened on top, abruptly elevated in front, descending more steeply to the ventral than to the dorsal and posterior margins. Marked about on the vertical mid-line by a subvertical deeply impressed cleft, extending from a little below the middle of the valve to about one-fourth the distance below the dorsal margin, where a short shallow extension flares abruptly forward. Anteriorly the surface is marked by a system of four, subquadrangularly arranged deep pits, each horizontal pair being noticeably confluent, the ridge between the two pairs more strongly elevated. Each of the two subhorizontal pairs of clefts represents one of the two anterior clefts of *T. ellipsoclefta,* the ends of those clefts being overdeepened, forming pits that are severed by shallowing of the medial portion. These pits generally conform to a distinctive pattern; the upper anterior pit is more elongated than the others, and parallels the adjacent part of the anterior margin, as does the much shorter lower anterior pit. The lower posterior pit tends to be moderately elongated, curving upward to the rear, while the long direction of the very short upper posterior pit is nearly vertical but bends a little forward above. The surface surrounding the pits forms a continuous rim that overhangs the slope to the anterior margin. The concavity below the rim is marked along the margin of the anterior third of the valve, and forms a furrow that ends rather suddenly at either end. This feature is not well shown in the side views for *T. secoclefta,* and should be more nearly as shown for *T. ellipsoclefta.* Some distance behind the

vertical submedian cleft is one small rounded pit, or in some cases two. Surface apparently without other ornament.

The larger figured left valve measures length 0.92 mm., height 0.53 mm., convexity or thickness about 0.23 mm.

Thlipsurella secoclefta is very close to *T. ellipsoclefta,* the shape, size, character of the submedian cleft, and convexity of the valve being very similar. It is also very similar to *T. multipunctata* (Ulrich and Bassler[6]) of the Shriver of Maryland, figured and described with similar anterior pits, but "with two, or rather three, elongated depressions paralleling the post-dorsal half."

Occurrence. Common 90 to 117 feet above the base of the Shriver chert at Hollidaysburg, Pennsylvania, common 75 feet and 105 to 110 feet above base of the Shriver at Lewistown, Pennsylvania, common in *Metaplasia plicata* zone of the middle part of the Shriver, and in the upper part of the Shriver at Curtin, Pennsylvania, rare in material from above middle of the Shriver at Jersey Shore, Pennsylvania.

THLIPSURELLA CURTINENSIS F. M. Swartz n. sp.
Plate 11, figures 4 a-c

Carapace small, subovate in dorsal view, suddenly expanded at the front, sides then nearly parallel for some distance, converging in the posterior third; subovate to suboblong in side view; ventral margin straight for some distance, or sinuate; dorsal margin gently convex; anterior margin more or less rounded, but distinctly blunter than the posterior margin; greatest length a little nearer the ventral than the dorsal margin, greatest height tending to be in front of the middle. Overlap and hingement not observed.

Surface of valve strongly convex, abruptly elevated in front, rising a little more steeply from the ventral than from the dorsal and posterior margins; marked just in front and a trifle above the middle by a rounded pit that looks as though it had been indented by the apex of a broad-based cone; while near to and paralleling the anterior margin is a rather long, narrow, slightly curved, moderately deep furrow, bounded in front and above and below by an elevated rounded rim, that merges at either end with the general surface of the valve. Surface apparently without other ornament.

A relatively large right valve measures length 0.51 mm., height 0.33 mm., convexity or thickness 0.14 mm.

This species has no known close relatives. It has been placed provisionally, and with hesitance, in the section of *T. ellipsoclefta,* chiefly because of the submedian depression. This depression, however, does not suggest the fairly long subvertical submedian furrow of *T. ellipsoclefta* and its close relatives. The shape of the carapace, and the single subvertical anterior cleft somewhat suggests the section of *T. oblonga,* but the typical members of that section have no submedian depression.

Occurrence. Common in the *Metaplasia plicata* zone of the middle part of the Shriver chert at Curtin, Pennsylvania.

[6] *Md. Geol. Survey,* Lower Devonian, p. 536, pl. 98, fig. 8, 1913.

THLIPSURELLA OBLONGA
(Ulrich and Bassler)
Plate 11, figures 1 a-c

Craterellina oblonga ULRICH AND BASSLER, *1913*, Md. Geol. Survey, Lower Devonian, p. 540, pl. 98, fig. 20.

Carapace subovate in dorsal view, rapidly expanded at the front, greatest thickness in front of the middle, declining toward the rear; subovate to suboblong in side view, dorsal margin a little more convex than the ventral margin, anterior end the blunter, broadly rounded to somewhat truncated; greatest height in front of the middle, greatest length a little nearer the ventral than the dorsal margin. Right valve distinctly overlaps the left, at least along the free margins. Hingement not observed in the material studied.

Surface of valve strongly convex, sloping more steeply to the ventral than to the dorsal and posterior margins; marked anteriorly by a large, deep, C-shaped cleft, the extremities of which nearly meet; the lower limb of the cleft is generally a trifle longer than the upper, and the cleft is distinctly shallower at the upper and lower bends than elsewhere. Area enclosed by the cleft elevated, flat-topped, rising above the level of the surrounding rim, connected to the general surface of the valve by the narrow isthmus lying between the extremities of the cleft; this isthmus is occasionally a little depressed. The cleft is bounded in front, and above and below, by a strongly elevated rim that rises steeply from the anterior margin. The rim is a little overhanging, the slope below it concave, so that there is a small lip-like projection at the anterior margin. At either end the rim merges into the general surface of the valve. Surface appears otherwise smooth.

A representative right valve measures length 0.86 mm., height 0.54 mm., convexity or thickness 0.25 mm.

Ulrich and Bassler described the surface sculpturing of this species as follows: "anterior half of valve with a ring-like ridge enclosing a depression from the center of which a small, rounded, cone-like prominence arises." This description fits much better the species *T. crateriformis*, as hereafter described. The type specimens of *Craterellina oblonga* at the National Museum are weathered carapaces, with the cleft more or less clogged with matrix. The cleft agrees in size and shape with that of the central Pennsylvania material placed in *T. oblonga*, and the summit of the area enclosed by the cleft rises to or a little above the crest of the surrounding rim, whereas in *T. crateriformis* the fold on the floor of the area enclosed by the cleft is very low, and its summit is much lower than the crest of the surrounding rim. In the types at the National Museum the "isthmus" joining the area enclosed by the cleft with the general surface of the valve, is obscured by the matrix clogging the cleft; but Dr. Bassler, with whom the matter was discussed, agreed that this isthmus is probably present.

Thlipsurella oblonga appears to agree exactly with *Craterellina moorei* Roth,[7] of the Haragan marl of

[7] Roth, Robert, *Jour. Pal.*, vol. 3, p. 362, pl. 37, figs. 22 a-b, 1929.

Oklahoma, except that the anterior end of the type specimen of the latter is rounded, whereas the anterior end of the type specimen of the former is truncated. This difference may make it possible to distinguish *moorei* as a variety of *T. oblonga,* although the outline of the anterior margin of both the Shriver and the Haragan material is subject to so much variation as to make the distinction of doubtful value.

Occurrence. Common 90 to 117 feet above the base of the Shriver at Hollidaysburg, Pennsylvania, and in the *Metaplasia plicata* zone of the middle part of the Shriver at Curtin, Pennsylvania.

THLIPSURELLA CRATERIFORMIS F. M. Swartz n. sp.

Plate 11, figures 2 a, b

Carapace subovate in dorsal view, suddenly expanded at the front, declining toward the rear, greatest thickness in front of the middle; subellipti cal to subreniform in side view, dorsal margin somewhat more convex than the ventral margin, anterior end a little higher than the posterior, and tending to be somewhat truncated; greatest height about at or a little in front of the middle; greatest length a little nearer the ventral than to the dorsal margin. Overlap and hingement not observed.

EXPLANATION OF PLATE 11

FIGS. 1*a-c*—*Thlipsurella oblonga* (Ulrich and Bassler). *a, b,* Side and dorsal views of right valve, with truncated anterior margin, × 29; *c,* side view of right valve with more rounded anterior margin, × 29; both from Hollidaysburg, Pennsylvania, 90-110 ft. above base of the Shriver chert.

2*a, b*—*Thlipsurella crateriformis* F. M. Swartz, n. sp. *a, b,* Ventral and side views of left valve, × 29; Curtin, Pennsylvania, *Metaplasia plicata* zone of middle part of the Shriver chert.

3*a, b*—*Thlipsurella orthoclefta* F. M. Swartz, n. sp. *a, b,* Side and ventral views of left valve, × 29, found in slab collected by J. B. Payne near Altoona, Pennsylvania, apparently from upper part of Shriver chert.

4*a-c*—*Thlipsurella curtinensis* F. M. Swartz, n. sp. *a, b,* Side and ventral views of right valve, × 29; *c,* left valve, × 29; both from Curtin, Pennsylvania, *Metaplasia plicata* zone of middle part of Shriver chert.

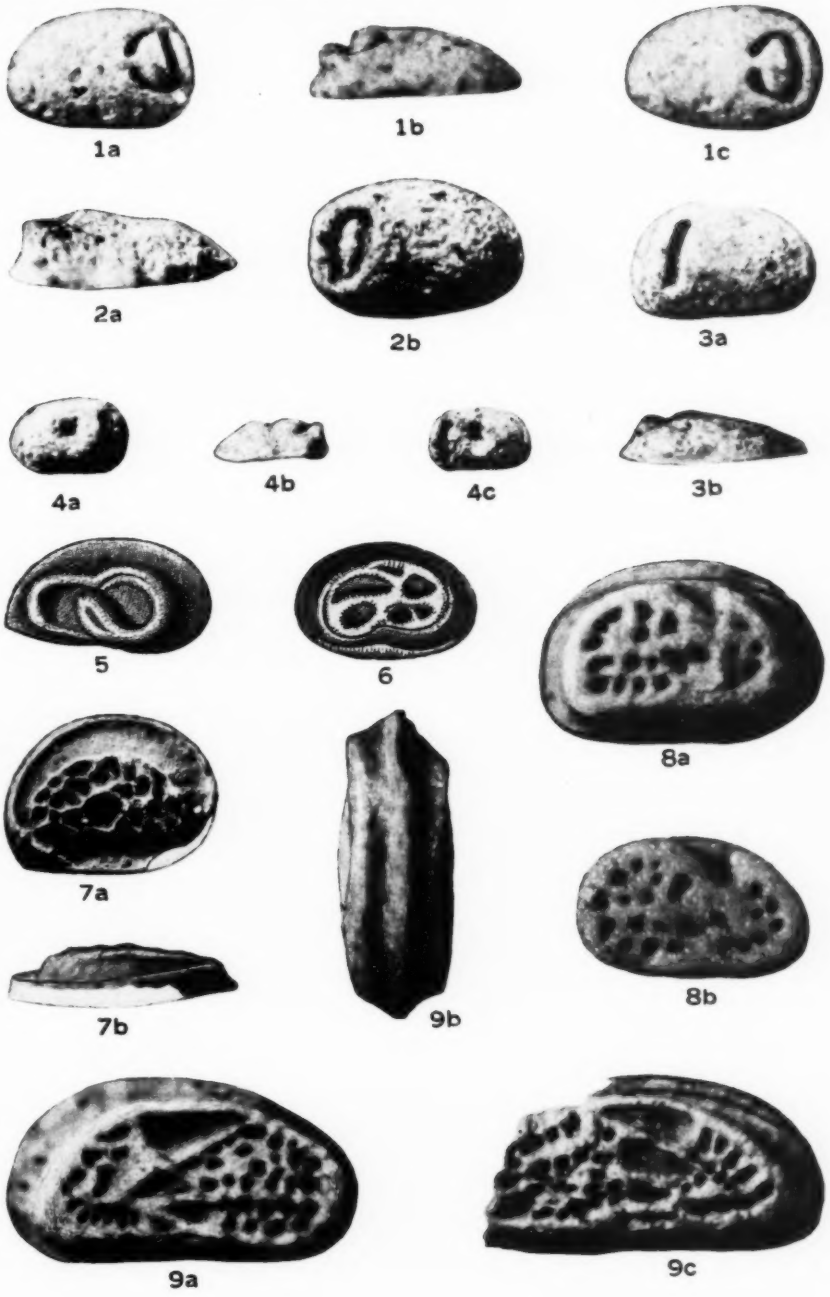
5—*Octonaria octoformis* Jones, the genotype. Left valve, × 20. Silurian of England, after Ulrich and Bassler.

6—*Octonaria ovata* Ulrich. Right (?) side of carapace, × 20. Middle Devonian, Onondaga limestone, Falls of the Ohio. After Ulrich and Bassler.

7*a, b*—*Octonaria altoonensis* F. M. Swartz, n. sp. *a, b,* Side and dorsal views of left valve, × 29; Altoona, Pennsylvania, 60 ft. above base of lower Devonian Keyser limestone.

8*a, b*—*Octonaria dorsosulcata* F. M. Swartz, n. sp. *a,* Right valve, × 29, retaining overlapping edge of left valve; *b,* right valve, × 29, the marginal flange not preserved; both from Hollidaysburg, Pennsylvania, 90-110 ft. above base of Shriver chert.

9*a-c*—*Octonaria deltisulcata* F. M. Swartz, n. sp. *a,* Left valve, × 29; *b,* dorsal view of carapace, incomplete ventrally and at posterior end, × 29; *c,* incomplete right valve, with part of overlapping edge of left valve, × 29. Note hingeline. All from Hollidaysburg, Pennsylvania, 90-110 ft. above base of the Shriver chert.



Swartz—Devonian ostracodes, Thlipsuridae

Surface of valve strongly convex, descending a little more steeply to the ventral than to the dorsal and posterior margins; marked anteriorly by a relatively large, deep, subelliptical to suboblong crateriform depression, elongated dorso-ventrally, but not quite vertical to the ventral margin; floor of the depression elevated into a low rounded fold or ridge running lengthwise of the depression, but not reaching either end; summit of the ridge much lower than the crest of the surrounding rim; outline of the depression a little distorted so that the greatest diameter is not in the direction of the ridge, but is the oblique diameter from the antero-ventral to the post-dorsal corners of the depression. The crateriform depression is bounded in front, below and above by a strongly elevated rim, that rises steeply, with a concave slope, from the adjacent parts of the margin. This rim merges at either end with the general surface of the valve. The surface of the valve is a little higher just behind the depression than elsewhere, and then is a little depressed to form a shallow "swayback." Surface appears smooth otherwise.

The figured left valve measures length 0.96 mm., height 0.63 mm., convexity or thickness 0.27 mm.

Thlipsurella crateriformis has essentially the features ascribed to *Craterellina oblonga* by Ulrich and Bassler. Examination of the types of the latter species shows that the elevation enclosed by the anterior cleft is large, and its summit rises to or a little above the crest of the surrounding rim.

Occurrence. Common in *Metaplasia plicata* zone of the middle part of the Shriver chert, Curtin, Pennsylvania.

THLIPSURELLA ORTHOCLEFTA F. M. Swartz n. sp.

Plate 11, figures 3 a, b

Carapace subovate in dorsal view, suddenly expanded at the front, greatest thickness in front of the middle, declining toward the rear; subovate, tending toward subreniform in side view, dorsal margin strongly convex, ventral margin nearly straight, anterior end the blunter, antero-ventral bend sharply turned, somewhat protuberant; greatest height in front of the middle, greatest length nearer the ventral than the dorsal margin. Right valve overlaps a little upon the left, apparently along the dorsal margin as as well as elsewhere; the hingement not well defined.

Surface of valve convex, sloping somewhat more steeply to the ventral than to the dorsal and posterior margins; marked near the front by a deep, relatively narrow, subvertical, almost staight cleft, that about parallels the anterior margin, and tends to flare a little forward below, and a little backward above. The cleft is bounded in front, above and below, by a strongly elevated rim, that merges at either end with the general surface of the valve. The surface slopes steeply and with a distinct concavity from the rounded summit of the rim to the anterior margin, the concavity of this slope producing a short lip-like extension along the anterior margin. Surface appears otherwise smooth.

A representative left valve measures length 0.90 mm., height 0.65 mm., convexity or thickness just behind cleft 0.21 mm.

Occurrence. Common 90 to 110 feet above the base of the Shriver at Hollidaysburg, Pennsylvania, rare 67 to 75 feet above the base of the Shriver at Lewiston, Pennsylvania, rare in upper part of Shriver at Corrigansville, near Cumberland, Maryland.

Genus OCTONARIA Jones

Octonaria JONES (part), *1887,* Ann. and Mag. Nat. Hist., (5) vol. 19, p. 400.—KRAUSE, *1891,* Zeits. deutsch. Geol. Gesell., vol. 43, p. 508.—ULRICH, *1891,* Jour. Cin. Soc. Nat. Hist., vol. 13, pp. 193, 194.—ULRICH AND BASSLER, *1913,* Md. Geol. Survey, Lower Devonian, pp. 537, 538; *1921,* Md. Geol. Survey, Silurian, p. 317, fig. 23: 3 and 4; also p. 701.—KUMMEROW, *1923,* Jb. Preuss. Geol. Landesanstalt für 1923, p. 434.

?Octonaria JONES, *1890,* Quart. Jour. Geol. Soc. London, vol. 46, p. 541.—KRAUSE, *1892,* Zeits. deutsch. Geol. Gesell., vol. 44, p. 396.—STEUSLOF, *1894, idem.,* vol. 46, p. 787.

Probably not *Octonaria* ROTH, *1929,* Jour. Pal., vol. 3, pp. 531, 532.

Characters of the Genus. Of the many species that have been assigned to this genus, several should be removed, the generic position of several others is very uncertain, and most of the remaining fall more or less naturally into four sections. As here understood, the essential features of the genus are as follows: Carapace of moderate size, up to 1.5 mm. in length; moderately thick, suboblong in dorsal view, the sides nearly parallel for most of the length of the carapace; subreniform to subovate in side view, the dorsal margin strongly convex, the ventral margin tending to be nearly straight, the antero-ventral bend tending to be sharply turned and somewhat protuberant; greatest length nearer the ventral than to the dorsal margin, greatest height more variable in position, frequently tending to be a little behind the middle. Hingement and overlap not always well understood, but there appears to be a tendency for the left valve to overlap the right, particularly along the hinge. Judging from Jones' illustrations this overlap is not well marked in the typical section of the genus. Surface of valve convex, largely elevated into a prominent, flattened plateau-like area, surrounded by a well marked, more or less flattened marginal flange that generally extends along the entire periphery; surface of the plateau area marked by strong depressions of greater or lesser size and number, and of various shapes; in the typical section these are relatively large, and only one or two in number; but in another section the surface tends to be marked by many small pits. These depressions do not reach the border of the plateau area, and the border consequently forms an unbroken, continuous rim, rising steeply from the marginal flange. Genotype *Octonaria octoformis* Jones, Tickwood beds of the Silurian of England.

Proposed sections. The suggested sections, the questionable and removable species are as follows:

1. Section of *Octonaria octoformis:*
   Octonaria octoformis Jones.[5]
   Octonaria octoformis var. *intorta* Jones.[5]
   Octonaria octoformis var. *simplex* Jones.[5]
   Octonaria octoformis var. *bipartita* Jones[5]

[5] European Middle and Upper Silurian species.

Octonaria octoformis var. *informis* Jones.[9]

2. Section of *Octonaria ovata:*
   Octonaria octoformis var. *persona* Jones.[9]
   Octonaria ovata Ulrich.[9]
   Octonaria deltisulcata F. M. Swartz n. sp.[10]
   Octonaria dorsosulcata F. M. Swartz n. sp.[10]
   Octonaria stigmata var. *loculosa* Ulrich.[9]
   Octonaria stigmata Ulrich.[9]
   Octonaria stigmata var. *oblonga* Ulrich.[9]
   Octonaria perplexa Kummerow.[5]
   Probably *Octonaria ? linnarssoni* Jones.[9]
3. Group of *Octonaria angulata:*
   Octonaria angulata Ulrich and Bassler.[10]
   Octonaria muricata Ulrich and Bassler.[11]
   Octonaria inequalis Ulrich and Bassler.[10]
   Octonaria altoonensis F. M. Swartz n. sp.[10]
4. Section of *Octonaria elliptica:*
   Octonaria elliptica Krause.[8]
   Octonaria bolii Steusloff.[5]
   Possibly *Octonaria bifasciata* Krause.[8]
   Possibly *Octonaria cranei* Ulrich and Bassler.[11]

Removable species:
   Octonaria undosa Jones.[8]
   Octonaria ? paradoxica Jones.[8]
   Probably *Octonaria punctata* Roth.[10]
   Probably *Octonaria bicava* Ulrich and Bassler.[10]

The typical section is marked by its subreniform outline, well developed marginal flange, the strong bordering rim of the plateau area, surrounding one or two large depressions. In *O. octoformis* var. *informis* the two depressions of the plateau area are reduced in size, as compared to the intervening ridge and surrounding rim. This form and *O. octoformis* var. *persona* with four depressions, comprise a connecting link between the typical section and that of *O. ovata.*

O. octoformis var. *persona* has one elongate depression, paralleling what should probably be considered the antero-dorsal margin, the other depressions being rounded pits. The large deltoid dorsal depression of *O. deltisulcata* possibly represents part of antero-dorsal depression of *persona,* the anterior part of the depression having broken up into a series of smaller pits. *O. dorsosulcata* is closely related to *O. deltisulcata,* but departs from the norm in that the subdeltoid dorsal depression breaks through the bordering rim of the plateau area. *O. stigmata* var. *loculosa* is many-pitted, as is normal for the section, but the pits are relatively weak, and arranged in several sublinear series. In *O. stigmata* and its variety *oblonga* these pits become confluent, forming irregular furrows. A sublinear arrangement of the pits is also developed to some extent in *O. deltisulcata* and *O. dorsosulcata.* With the exception of *O. octoformis* var. *persona* the members of the *O. ovata* section so far discussed are either Lower Devonian, or lower Middle Devonian species. The Middle Devonian Hamilton shale species, *O. linnarssoni,* also appears to belong with the weakly multi-pitted, furrowed species of this section, although as figured by Jones the dorsal margin is straight, and the greatest length is near the dorsal margin, the supposed post-dorsal region being strongly protuberant. The flattened marginal flange fails along the supposed dorsal margin. If this species could be reversed

[9] American Middle Devonian species.
[10] American Lower Devonian species.
[11] American Middle or Upper Silurian species.

dorsoventrally, its position in *Octonaria,* as well as in this section, would be very much more satisfactory. *O. perplexa* is an elongate multi-pitted species figured without a marginal flange, and consequently appearing peculiar for this section and for the genus. It is desirable to determine with certainty whether the absence of the flange is due to accident, or is a specific feature.

O. angulata is a rather high species, strongly angulated in outline antero-ventrally, the flange well developed, but bearing a distinct rim along its margin, the tabular area marked by two strong longitudinally elongate furrows. *O. muricata* is very similar to *O. angulata,* but is apparently subelliptical in outline, and not angulated antero-ventrally. It also has a peculiar pit in the floor of one of the furrows. A somewhat similar pit is also seen in *O. bifasciata* Krause and *O. linnarssoni. O. inequalis* also is marked by relatively strong longitudinal clefts, and is subreniform in outline, although the antero-dorsal bend is not strongly angulated. It is abnormal for *Octonaria* because of the exceptional inequality of the valves, the left strongly overlapping the right along all the margins. The inclusion of *O. altoonensis* in this section is perhaps open to question, as the surface of the plateau area is marked by a large number of pits. In detail, however, the pitting does not suggest that of any of the described members of the *O. ovata* section, and the species is placed with *O. angulata,* because of the strongly angulated antero-ventral bend, the proportionally great height of the carapace, and particularly because of the peculiar rim around the periphery of the marginal flange. The last mentioned character is shared by this species, *O. angulata* and *O. muricata.*

O. elliptica somewhat resembles *O. simplex* and *O. monticulata* of the *O. octoformis* section, in that the plateau area is represented by a strong rim enclosing a single large depression. It differs however in that it is equal-ended and is not subreniform but subelliptical in outline. *O. bollii* is near *O. elliptica,* but the rim is thinner, a marginal flange is apparently wanting, and the outline tends to be suboblong. *O. cranei* is also equal-ended and suboblong, and has a fairly strong marginal flange, but differs from the above species in the much greater thickness of the border of the plateau area, which encloses a relatively narrow but irregularly elongate depression. Ulrich and Bassler consider *O. cranei* "the earliest known of the *O. stigmata* group." It's position in the *O. elliptica* section is unsatisfactory. *O. bifasciata* is a questionable species not only for this section, but also for *Octonaria.* The rim of the plateau area is represented by two semielliptical ridges, one paralleling each end of the valve, their ends overlapping. The greatest length is nearer the dorsal than the ventral margin. As in the case of *O. linnarssoni,* this species would fit *Octonaria* better if the orientation were reversed dorso-ventrally.

Removable and questionable species. Among the other species that have been assigned to *Octonaria, O. undosa*

Jones and *O. paradoxica* Jones have straight dorsal margins and they do not have the tabular area of *Octonaria.* Instead, there is an elongated elevated area parallel to the ventral margin and three stout lobes project vertically from this elevation toward the dorsal margin. In their general appearance these two species somewhat resemble *Beyrichia fodicata* Jones and Kirkby, assigned by Ulrich and Bassler to *Jonesina.*[12] Whatever their proper generic position, it seems obvious that they should be removed from *Octonaria. O. bicava* Ulrich and Bassler is a species from the Eden of Kentucky, that has a short straight hinge, is equal-ended, the figured valve is convex, is marked near the center by two small pits, a little elongated vertically, and is a little enlarged along the margin, apparently to overlap the other valve. This species is not suggestive of any of the other described species of *Octonaria,* and besides having an incorrect outline, lacks a true marginal flange, unless the overlapping enlargement be considered as such. Its relationships to *Octonaria* is also made questionable because of its age, as it is an Ordovician species, whereas the earliest known normal species are from the Middle Silurian. Maryland Lower Devonian specimens of *Thlipsura simplex* Krause have been referred provisionally to *Octonaria* by Ulrich and Bassler. That species lacks the marginal flange of *Octonaria,* and has the edge view outline of *Thlipsurella,* in which it is provisionally placed in this paper. Finally, *O. punctata* Roth is a more or less subelliptical species, without a true marginal flange, and without the strong surface markings typical of *Octonaria.* Furthermore, the valves are extremely unequal, more so even than in *O. inequalis.* Reference of this species to *Octonaria* is very questionable; unfortunately, its relationships to other described genera are also obscure.

[12] See *U. S. Nat. Museum Proc.,* vol. 35, pp. 324, 325.

OCTONARIA DELTISULCATA F. M. Swartz, n. sp.

Plate 11, figures 9 a-c

Carapace of moderate size; subobblong in dorsal view, the sides nearly parallel for most of the length of the carapace; elongate subreniform in side view, the dorsal margin strongly convex, the ventral margin nearly straight or sinuate, the posterior margin more regularly rounded than the anterior, the anterior margin tending to be most protuberant in its lower part; greatest length nearer the ventral than to the dorsal margin, the greatest height about at or a little in front of the middle. Valves somewhat unequal; left valve strongly overlapping the right along the hinge, so that in the right valve the marginal flange fails here, although it is well developed here as elsewhere on the left valve; overlap less marked along the free edges.

Surface of valve strongly elevated into a large flattened tabular or plateau-like area, occupying most of the surface of the valve, but surrounded along the entire periphery by a well marked flattened marginal flange, that is widest along the antero-dorsal part

of the margin. The elevated tabular area has much the outline of the valve as a whole, but is more sharply turned and protuberant at the antero-ventral bend, and above this the anterior margin is bent more obliquely backward. The border of the tabular area forms a continuous unbroken rim, very sharply elevated above the flange and a little overhanging along its posterior and dorsal and ventral margins, but sloping less steeply to the flange in front. The surface of the tabular area is marked within the border by about 45 relatively deep depressions and pits. These are dominated by a large subdeltoid depression lying with its longest side along the dorsal border of the tabular area, a little in front of the middle of the valve. The ridge along the post-ventral margin of this depression is extended forward and downward, and to some extent tends to separate from the rest of the surface the double row of about eight small rounded to subangular pits that parallels the anterior margin. A single row of six or seven pits extends from this double row parallel to the antero-ventral border of the tabular area. Just above the middle of the ventral margin of the tabular area is a rather small subtriangular pit, from which a double row of nine or ten small pits extends backward parallel to the post-ventral margin of the tabular area. These are separated by a rather distinct but low ridge from the overlying fifteen to twenty pits, headed by a third subtriangular depression that lies a little in front of the middle of the tabular area. The depressions of the tabular area thus fall into three major divisions. In the one specimen 2 pits are separated off from the anterior part of the submedian subtriangular depression, and there is a row of 3 small pits below the lower small subtriangular depression.

Length of the figured left valve 1.45 mm., height 0.82 mm., greatest convexity 0.32 mm.

The only known close relative of this species is *O. dorsosulcata,* hereafter described. The large deltoid depression, and peculiar tripartite arrangement of the surface markings separates it from the many-pitted *O. stigmata* var. *loculosa* Ulrich.

Occurrence. Fairly common about 90 to 100 feet above the base of the Shriver chert at Hollidaysburg, Pennsylvania.

OCTINARIA DORSOSULCATA F. M. Swartz n. sp.

Plate 11, figures 8 a, b

Carapace suboblong in dorsal view, sides flattened and nearly parallel for most of the length, greatest thickness a little behind the middle; subreniform in side view, the dorsal margin strongly convex, the ventral margin nearly straight, the posterior margin more regularly rounded than the anterior, the anterior margin tending to be a little more protuberant in its lower part than elsewhere; greatest length nearer the ventral than to the dorsal margin, greatest height about at the middle; valves a little unequal, the left valve strongly overlapping the right along the hinge, its overlap less pronounced along the free margins.

Surface of valve strongly elevated into a large flattened tabular, or plateau-like area, that occupies most of the surface of the valve, but surrounded along the entire periphery by a well marked flattened marginal flange. The border of the tabular area is steeply elevated, above the marginal flange, somewhat overhanging along the posterior, dorsal and ventral margins, but the slope to the marginal flange is less steep along the anterior margin. The border of the tabular area is unmarked and continuous except a little in front of the middle of its dorsal margin, where it is broken or indented by a short sulcus extending downward and forward. Extending from this sulcus is a series of about six or seven rounded pits, paralleling the anterior and antero-ventral margin of the tabular area. The first one or two of these pits is somewhat confluent with the dorsal sulcus. A double row of about eight or ten pits parallels the post-ventral half of the margin of the tabular area, and these are more or less separated from the six or eight overlying pits by a broad low ridge.

The figured right valve, preserved with the flanges of both valves, measures length 1.11 mm., height 0.77 mm., maximum convexity or thickness of the one valve 0.27 mm.

This species is close to *O. deltisulcata,* with which it occurs, the tripartite arrangement of the pits and depression being similar. It is however smaller, less elongate, the pits are much less numerous, and the large dorsal depression breaks through the border of the tabular area.

Occurrence. Fairly common 90 to 110 feet above the base of the Shriver chert at Hollidaysburg, Pennsylvania.

OCTONARIA ALTOONENSIS F. M. Swartz n. sp.

Plate 11, figures 7 a, b

Carapace small, suboblong in dorsal view, greatest thickness behind the middle; subreniform, short and high in side view, dorsal margin strongly convex, ventral margin straight, posterior margin broadly and regularly rounded, anterior margin rounded above, sharply angulated below; greatest length nearer the ventral than the dorsal margin, greatest height about at or a little behind the middle. Overlap and hingement not observed.

Middle part of valve elevated into a moderately large tabular area, higher behind and above, lower in front and below. This has much the outline of the valve as a whole, but is less high and more elongate. It is surrounded by a continuous wide flattened marginal flange, the periphery of which is surmounted by a well defined, continuous rim. This rim rises very steeply from the edges of the valve, except at the antero-ventral bend, where the rim is set a little distance away from the edge, and so does not fully share the angulation of the valve margin. Surface of the tabular area marked by about 24 pits, dominated by an exceptionally large rounded pit just above the middle of the ventral margin of the tabular area. The other pits are of various shapes, generally subangular in outline, and are separated by exceptionally thin ridges.

Length 0.93 mm., height 0.66 mm., convexity of the left valve, 0.21 mm.

The outline, and the rim surmounting the periphery of the flange, are suggestive of *O. angulata* Ulrich and Bassler of the Keyser limestone of Maryland. The ornamentation of the tabular area is very different, as in that species the tabular area is marked by two strong longitudinal clefts. None of the other pitted species of this genus are at all similar.

Occurrence. Rare 60 feet above the base of the Keyser limestone member of the Lower Devonian Helderberg group, at Altoona, Pa., occurring with *Leperditia gigantea, Kloedenia centricornis,* and other ostracodes. The Keyser is only 98 feet thick at this locality. *Stenochisma deckerensis* and *Nucleospira swartzi* are common in the lower 8 feet, *Cladopora rectilineata* and other corals are abundant 26 to 35 feet above the base; the beds from 45 feet to the top are mostly thin-bedded and laminated, except for two large Stromatoporoid ledges at 50 to 58, and 65 to 69 feet. The Keyser is overlain by the Coeymans limestone, 10 feet thick, with *Gypidula coeymanensis* and other fossils.

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A PENNSYLVANIAN CEPHALOPOD FAUNA FROM SOUTH-CENTRAL NEW MEXICO

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ABSTRACT

In 1920, Emil Böse published a preliminary report on a late Paleozoic cephalopod fauna from near Tularosa, New Mexico, and showed that it was Upper Pennsylvanian in age; he believed that it came from a southern extension of the Abo sandstone. The collection studied by him is described below and his age-determination is confirmed, but the correlation of the strata from which it came with the Abo is questioned. The collection includes specifically recognizable representatives of two genera of nautiloids and four genera of ammonoids, two of which are new. Both of the nautiloid genera and three of the ammonoid genera are discussed at some length. Two new species of nautiloids and two known and eight new species of ammonoids from the sandstone near Tularosa are described, and a redescription of the type of the ammonoid genus *Millerоceras* is included.

In 1920 Emil Böse[1] published a preliminary account of a late Paleozoic cephalopod fauna that C. L. Baker and N. F. Drake had discovered in the lower part of a sandstone formation one and one-fourth miles due east of Tularosa, New Mexico, on the road to the Mescalero Apache Reservation. The fossils came from shale beds about 200 feet above the base of the formation, which is stated to have a thickness of about 1,400 feet some five miles north of there. Due to Böse's unfortunate death in 1927, a final report on this fauna was never completed. Prof. Charles Schuchert purchased the collection on which the preliminary report was based, along with other fossils from Böse's estate, and deposited it in Peabody Museum of Natural History, Yale University, whence it was made available for study by the writer due to the kindness of Prof. Schuchert and Prof. C. O. Dunbar. The present report consists almost entirely of a detailed study of this collection and the literature dealing with the paleontology and stratigraphy of the region from which it came.

Böse believed the formation that yielded the fossils to be a southern extension of the Abo sandstone, and his preliminary report was published with the view of establishing the age of that formation. Because of this fact, he discussed only the ammonoids, as he recognized that they alone were sufficient to fix the age of the containing strata. As a matter of fact, they constitute the bulk of the collection, but in addition two nautiloid genera are represented by specifically recognizable material, and the collection contains also a small fragment of a third nautiloid that appears to resemble the

[1] Böse, Emil, On ammonoids from the Abo sandstone of New Mexico and the age of the beds which contain them: *Am. Jour. Sci.*, ser. 4, vol. 49, pp. 51-60, 1920.

form that is commonly identified as *Tainoceras occidentale* (Swallow), and a single gastropod which evidently should be referred to the genus *Bellerophon;* the two specimens mentioned last are fragmentary and are not well enough preserved to merit detailed description.

The writer has not had an opportunity to visit the locality from which these fossils came or to study the type section of the Abo sandstone, which is at Abo Canyon at the southern end of the Manzano Range, about 100 miles north and slightly west of Tularosa, but from a study of the fossils alone and a comparison of them with those that have been identified from nearby areas, certain conclusions have been reached that are believed to be worth recording. In 1909, Lee[2] defined the Abo sandstone and published a description of it and the associated formations; his report was accompanied by an account of the fauna by Girty. Lee considered the Abo as the lowermost of a group of three formations to which he applied Herrick's term Manzano group; the other two formations referred to this group are the Yeso and the San Andreas. Lee states that the Abo "rests unconformably upon the Magdalena group" and "consists of coarse-grained sandstone, dark red to purple in color and usually conglomeratic at the base, with a subordinate amount of shale, which attains prominence in some places"; the overlying Yeso formation apparently rests conformably on the Abo. Both Girty and Lee referred all of the Manzano group together with the underlying Magdalena group to the Pennsylvanian, and the following fossils were identified from "earthy limestone near the base of the Abo sandstone in Abo Canyon."

Fauna of the lower Abo sandstone in Abo Canyon, New Mexico

Lophophyllum? sp.
Septopora aff. *S. robusta*
Meekella striaticostata
Productus cora
Productus nebraskensis
Composita subtilita
Edmondia gibbosa
Chaenomya leavenworthensis
Leda obesa
Aviculipinna? peracuta
Aviculipinna nebraskensis
Monopteria marian
Pseudomonotis hawni?
Myalina apachesi
Schizodus wheeleri
Deltopecten occidentalis
Deltopecten manzanicus
Deltopecten coreyanus?
Allerisma capax
Pleurophorus aff. *P. subcostatus?*
Pleurophorus aff. *P. oblongus*
Patellostium aff. *P. nodicostatum*
Bucanopsis modesta?
Naticopsis deformis
Soleniscus aff. *S. altonensis*
Orthoceras sp.

Later (1920), Böse,[3] after considerable field work in the area involved and a preliminary study of the fauna described below, concluded that the Abo was Upper Pennsylvanian in age whereas the overlying Yeso and San Andreas were Permian, and that the Pennsylvanian and Permian systems

[2] Lee, W. T., and Girty, G. H., The Manzano group of the Rio Grande Valley, New Mexico: *U. S. Geol. Survey,* Bull. 389, pp. 10-13, 1909.

[3] *Op. cit.*

were not separated by an unconformity in this area. Baker[4] also has published an account of the formations under consideration. He was uncertain in regard to the age of the Abo but mentioned that Böse believed it to be Upper Pennsylvanian; the Yeso and San Andreas were regarded by him as undoubted Lower Permian. Still more recently, Darton[5] has discussed the general nature and distribution of the Abo, and on the basis of marine invertebrates identified by Girty, plants identified by David White, and vertebrates identified by Williston and Case, he referred the formation to the Permian. There is no reason to doubt that the faunas listed by Darton are of Permian age, but it seems to the writer that the faunal lists given are not convincing that all of the various units referred to the Abo by him are correlative, or that any of them are correlative with the Abo sandstone at Abo Canyon—though they may well be. Furthermore, since not a single ammonoid was present in the fauna obtained from the type section of the Abo, and since the fauna described below consists almost entirely of ammonoids and was collected about one hundred miles from that type section, it is anything but certain that both faunas came from the same formation.

It seems to the writer that the fauna that has been identified from the type section of the Abo (listed above) is not diagnostic of either the Pennsylvanian or the Permian, and that until more and better fossils have been obtained from undoubted outcrops of that formation, its age will have to remain uncertain. On the other hand, the fauna described below does not contain a single form that is closely related to Permian species, but is composed entirely of forms with a distinct Pennsylvanian aspect. The later Paleozoic nautiloids have not as yet been differentiated carefully enough to permit detailed correlations to be based on them, but all three of the nautiloid species represented in the collection being studied are closely related to Pennsylvanian forms. Among the ammonoids obtained from near Tularosa, *Gurleyoceras discoidale* (Böse) is strikingly similar to *G. welleri* (Smith) of the Cisco (Wayland shale) of Texas and is somewhat comparable to *G. gracile* (Girty) of the Wewoka of Oklahoma, and the genus is not known to be represented in the Permian. *Gastrioceras subtilicostatum* Böse and *G. angusticameratum* A. K. Miller, n. sp., of the Tularosa fauna are very closely related to *G. subcavum* (Miller and Gurley) of the Upper Pennsylvanian of Illinois and the Cisco (Wayland) of Texas; and as pointed out by Böse, "in the Permian most of the species of *Gastrioceras* belong to the very characteristic group of *G. zitteli*, while the Pennsylvanian types are rather rare in this system. In the . . . sandstone of Tularosa, on the contrary, the group of *G. zitteli* is entirely absent, while Pennsylvanian forms occur in abundance." It is not possible to point out

[4] Baker, C. L., Contributions to the stratigraphy of eastern New Mexico: *Am. Jour. Sci.*, ser. 4, vol. 49, pp. 108-112, 1920.

[5] Darton, N. H., "Red Beds" and associated formations in New Mexico: *U. S. Geol. Survey*, Bull. 794, pp. 20-21, 1928.

specific similarities in the case of the other two ammonoid genera represented in the collection, *Milleroceras* and *Wiedeyoceras,* but as far as is now known both are confined to strata older than the Permian. There seems to be little reason, therefore, to doubt that the fauna under consideration is definitely of Pennsylvanian age, and since the only two ammonoid species that are closely related to described forms are strikingly similar to those that occur in the Wayland shale member of the Graham formation of the Cisco, it seems logical to regard the sandstone at Tularosa as of Upper Pennsylvanian age and as the time equivalent of the lower part of the Cisco.* It is probably a northwestern extension of part of the Upper Pennsylvanian series (Gaptank) of western Texas, but since only one ammonoid fauna is known from that series, and since that fauna is distinctly younger than the one under consideration and is limited to the uppermost part of the Gaptank (the western equivalent of the Canyon and the Cisco), it is not now possible to state just which of the western Texas strata are equivalent to the ammonoid beds of Tularosa, or which (if any) are equivalent to the Abo formation at Abo Canyon.

* See note at end of paper.

SYSTEMATIC DESCRIPTIONS

Genus ENDOLOBUS Meek and Worthen

The generic name *Endolobus* was proposed by Meek and Worthen[6] in 1865 and one species, *Nautilus* (*Endolobus*) *peramplus* M. and W. of the Chester of Illinois, was referred to it. This species then became the genotype, but in 1866, Meek and Worthen[7] showed that it is conspecific with *Nautilus spectabilis* M. and W. (1860) of the same horizon and locality, and that species therefore is the genotype; it has since been identified from the Chester of Missouri and the Maxville of Ohio.

Meek and Worthen believed this generic term to be a synonym of *Bisiphytes* de Montfort (1808), which name, however, they thought should not be used because it "implies a direct contradiction of fact." It is true that de Montfort[8] based his genus on a misconception, but in as much as he complied with all the requirements of the International Rules of Zoological Nomenclature in proposing the name, it is necessary to recognize that he established it. However, since he designated *Bisiphytes reticulatus,*[9] a deeply

[6] Meek, F. B., and Worthen, A. H., Contributions to the palaeontology of Illinois and other western states: *Acad. Nat. Sci. Phila. Proc.*, 1865, p. 259.

[7] Meek, F. B., and Worthen, A. H., Descriptions of invertebrates from the Carboniferous system: *Ill. Geol. Survey,* vol. 2, pp. 308-309, 1866.

[8] Denys de Montfort, Pierre, *Conchyliologie systématique* . . . . , vol. 1, pp. 54-56, Paris, 1808.

[9] A rather crude figure of this species accompanies the original generic diagnosis and in addition one reference is given in the synonomy: *"Nautile à deux siphons.* Hist. nat. des Mollusques. Buffon, édit. de Sonnini, vol. 4, p. 208, pl. XLVI, fig. 2." Both figures appear to represent the same species and possibly the same specimen, and in the earlier publication the nature of the sutures as well as the ornamentation of the conch are shown fairly clearly. Furthermore, the specimen is said to have come from "Sombrenon en Bourgogne," and therefore it

involute, non-nodose nautiloid with a very small umbilicus, as the type of his genus, there is no reason to regard *Endolobus* as a synonym of it, or even to believe that the two are at all closely related.

In 1876, Meek[10] stated that he believed *Endolobus* could not be sustained but would have to be regarded as a synonym of *Temnocheilus* M'Coy (1844). However, the genotype of *Temnocheilus, Nautilus* (*Temnocheilus*) *coronatus* M'Coy[11] of the Mississippian of Ireland and England, is so different from the type of *Endolobus* that there is little reason to regard the two as congeneric. Its conch is much more strongly depressed dorsoventrally and almost subangular laterally, the nodes on the lateral zones of its conch are longitudinal rather than oblique, and at maturity the sutures form broad shallow saddles rather than lobes as they cross the venter.

Cryptoceras D'Orbigny (1850) (homonym of *Cryptoceras* Barrande, 1846) is also now generally regarded as a synonym of *Temnocheilus* and therefore *Endolobus*. The type of that genus is *Nautilus subtuberculatus* G. and F. Sandberger[12] of the Devonian of Germany. The lateral nodes on its conch are small, rounded, and distant (there are only seven or eight of them to a volution and they are separated by three or four camerae), the umbilicus is not perforate, and the siphuncle is close to the ventral wall of the conch. Therefore, it seems necessary to recognize that this species is not congeneric with the type species of *Endolobus, Bisiphytes,* or *Temnocheilus,* and that all four are generically distinct.

As near as the writer has been able to tell from the literature and the specimens available for study, the following species possess the same general characters as the genotype of *Endolobus* and should therefore be referred to that genus: *Temnocheilus conchiferus* Hyatt of the Carboniferous of Texas, *Nautilus* (*Temnocheilus*) *coxanus* Meek and Worthen of the St. Louis group of Indiana and Illinois and possibly the Carboniferous of Ballinger, Texas; *Temnocheilus crassus* Hyatt and *Temnocheilus depressus* Hyatt of the Lower Pennsylvanian (Fort Scott) of Kansas; *Nautilus forbesianus* McChesney of the Pennsylvanian of Illinois, Indiana, Ohio, Texas and Missouri; *Temnocheilus greenense* Miller and Gurley of the Chester of Indiana; *Endolobus ornatus* Girty of the Moorefield shale of Arkansas; *Nautilus ortoni* Whitfield of the Lower Pennsylvanian of Ohio; *Nautilus acanthicus* Tzwetaev and

seems very likely that workers in east-central France will be able to recognize the species. The supposed second siphuncle probably was a deep, narrow dorsal lobe of the septa.

[10] Meek, F. B., A report on the invertebrate Cretaceous and Tertiary fossils of the Upper Missouri Country: *U. S. Geol. Survey Terr.* (Hayden), vol. 9, p. 492, 1876.

[11] Originally figured and briefly described by Frederick M'Coy, in A synopsis of the characters of the Carboniferous limestone fossils of Ireland, pp. 20-21, pl. 4, fig. 15, London, 1844; and later described in detail by the same author in A synopsis of the classification of the British Palaeozoic rocks [by Adam Sedgwick] . . . with a systematic description of the British Palaeozoic fossils . . . pp. 557-558, London, 1855.

[12] Originally described by Sandberger, Guido, and Sandberger, Fridolin, *Die Versteinerungen des rheinischen Schichtensystems in Nassau,* pp. 133-134, pl. 12, figs. 3a-3e, Wiesbaden, 1850-1856.

Nautilus posttuberculatus Karpinsky of the Lower Pennsylvanian of central Russia; *Nautilus multituberculatus* Waagen of the Upper Productus limestone of the Salt Range of India; and probably the forms described but not figured by Girty (U. S. Geol. Survey Bull. 389, pp. 114-115, 1909) as "*Temnocheilus* aff. *conchiferum* Hyatt" from the San Andreas and Yeso formations of New Mexico, and "*Temnocheilus* sp. *a*" from the Yeso, Abo, and San Andreas formations of New Mexico. The genus therefore appears to range from Upper Mississippian to uppermost Permian but to be most abundant in the Pennsylvanian.

Nautilus avonensis Dawson, *Nautilus missouriensis* Swallow, *Endolobus gibbosus* Hyatt, *Solenocheilus indianensis* Worthen, and *Nautilus latisinuatus* De Koninck, which have been referred to this genus by other authors, probably should be excluded from it. The first of these species is non-nodose and has been made the type of a new genus, *Diodoceras* Hyatt (1900). The original description of the second is not accompanied by an illustration, is very brief and generalized, and the type has been lost; until topotype material has been collected and studied it will not be possible to place the species definitely in any genus, but in as much as its conch apparently is non-nodose, it should not be referred to *Endolobus*. The third species is the type of *Stearoceras* Hyatt (1900). The fourth is a typical representative of *Solenocheilus* and should be left in that genus. The last is based upon a single fragmentary specimen and is so incompletely known that it is not possible to place it definitely in any genus.

The genus *Endolobus* can be briefly characterized as follows: Conch nautiliconic, and whorls are typically depressed dorso-ventrally, broadly rounded ventrally, narrowly rounded laterally, distinctly impressed dorsally, and therefore subelliptical in cross-section. Umbilicus broad, moderately deep, and perforate. Growth-lines indicate the presence of a broad, deep, tongue-shaped hyponomic sinus but no lateral ones. Lateral zones of conch marked by numerous, prominent, more or less elongated nodes which are oblique to the long axis of the conch and slope apicad from the venter; they are equally prominent on the internal mold. Sutures simple and approximately transverse to long axis of conch, but slightly sinuous; they are nearly straight (or only slightly sinuous) on the lateral sides of the conch but form broad, shallow, rounded lobes as they cross the venter and broad, subangular lobes as they cross the dorsum. Septa also approximately transverse to long axis of conch and moderately convex apicad. Siphuncle small, subcentral in position, and orthochoanitic in structure; septal necks straight and moderately long (about one-fourth as long as camerae); connecting rings not expanded within camerae and siphuncular segments are therefore cylindrical in shape.

ENDOLOBUS SCHUCHERTI A. K. Miller, n. sp.
Plate 12, figures 12, 13

Conch nautiliconic and moderately rapidly expanded orad; whorls are

depressed dorso-ventrally, broadly rounded ventrally, narrowly rounded but somewhat flattened laterally, slightly impressed dorsally, and therefore subelliptical in cross-section. At adoral end of holotype, which consists of almost two volutions, maximum diameter of specimen measures about 32 mm.; maximum height of whorl, about 13.5 mm.; maximum width of whorl, which is attained near mid-height of conch, about 22 mm.; and maximum depth of impressed zone, about 2 mm.

Umbilicus wide, moderately deep, and perforate, and much of inner volution of conch is exposed. Diameter of umbilicus is slightly greater than half that of specimen and umbilicus is about half as deep as wide. The central perforation is oval and its two diameters measure about 4 mm. and 2.5 mm. Earliest volution of conch is not impressed dorsally, and extreme adapical part of conch, which is expanded orad more rapidly than rest of conch, appears to be circular or nearly so in cross-section and to become elliptical gradually during adolescence; at adoral end of first volution the two diameters of the conch measure about 5.5 mm. and 10 mm.

Test thin and marked by fine transverse growth-lines; the course of these growth-lines across the venter unfortunately cannot be determined from the type material. Lateral zones of internal mold of conch marked by very distinct elongated nodes which are oblique to the long axis of the conch and slope apicad from the venter. There is one node to each camera; they are less than ½ mm. high on the holotype and are discernible only near the center of the lateral zones of the specimen. The first whorl is nonnodose with the exception of its extreme adoral part on which the lateral nodes begin suddenly; the first is just as prominent as are the following ones. There is a very faint median longitudinal ridge on the venter of the holotype, but no other markings except the sutures are visible on the internal mold.

Length of camerae varies slightly but increases progressively orad and in general is equal to about one-third of the dorso-ventral diameter of conch. Sutures simple and approximately transverse to long axis of conch but slightly sinuous. They are essentially straight (curved apicad very slightly) on the lateral sides of the internal mold, but they form broad, shallow, rounded lobes as they cross the ventral side and broad, shallow, subangular lobes as they cross the dorsal. The sutures on the extreme adapical part of the conch appear to be simple circles transverse to the long axis of the conch. Sinuosity is developed in them gradually during adolescence; the dorsal lobes are recognizable in all but the adapical half of the first whorl, whereas the ventral ones can be recognized only in the adoral half of the last whorl of the holotype.

Internal structures of holotype not visible, but in a small moderately well preserved but very incomplete paratype, which represents only part of the inner whorl, the septa are moderately convex apicad and the siphuncle is small, intermediate in position, and

orthochoanitic in structure. Its diameter is equal to only about one-twelfth of the dorso-ventral diameter of conch, and it is located approximately midway between the center and ventral side of conch. The septal necks are straight and appear to be about one-fourth as long as camerae; connecting rings also straight and not expanded appreciably within camerae, and segments of siphuncle are therefore cylindrical in shape.

The specific name is given in honor of Prof. Charles Schuchert, of Yale University.

Remarks. The above description is based largely on a single well preserved internal mold which represents two whorls of the phragmacone, but three fragmentary paratypes are available for comparisons. One of the latter retains a mold of its siphuncle, but unfortunately that specimen is somewhat distorted, and whereas the structure of the siphuncle can be made out with certainty, a satisfactory illustration of it cannot be obtained.

This form is so distinct from all described species that comparisons seem unnecessary. So little information is available in regard to the forms from the Yeso, Abo, and San Andreas formations of New Mexico that were described but not figured by Girty (U. S. Geol. Survey Bull. 389, pp. 114-115, 1909) as *"Temnocheilus* sp. *a,"* that adequate comparisons can not be made.

Occurrence. Upper Pennsylvanian (Abo?) sandstone, one and one-fourth miles east of Tularosa, New Mexico.

Types. Peabody Museum of Natural History, Yale University, 13079.

Genus Stenopoceras Hyatt

In 1893, Hyatt[13] recognized that the forms he had previously referred to *Phacoceras* were not all congeneric, and he established the genus *Stenopoceras* for one group of them. *Phacoceras dumbli* Hyatt of the

[13] Hyatt, Alpheus, Carboniferous cephalopods; second paper: *Texas Geol. Survey,* Ann. Rep. 4, pp. 446-447, 1893.

Explanation of Plate 12

With the exception of the holotype of *Milleroceras parrishi* [figs. 5-7], all specimens figured are from Upper Pennsylvanian (Abo?) sandstone, 1.25 miles east of Tularosa, New Mexico; the holotype of *M. parrishi* is from the Kansas City formation, Kansas City, Missouri.

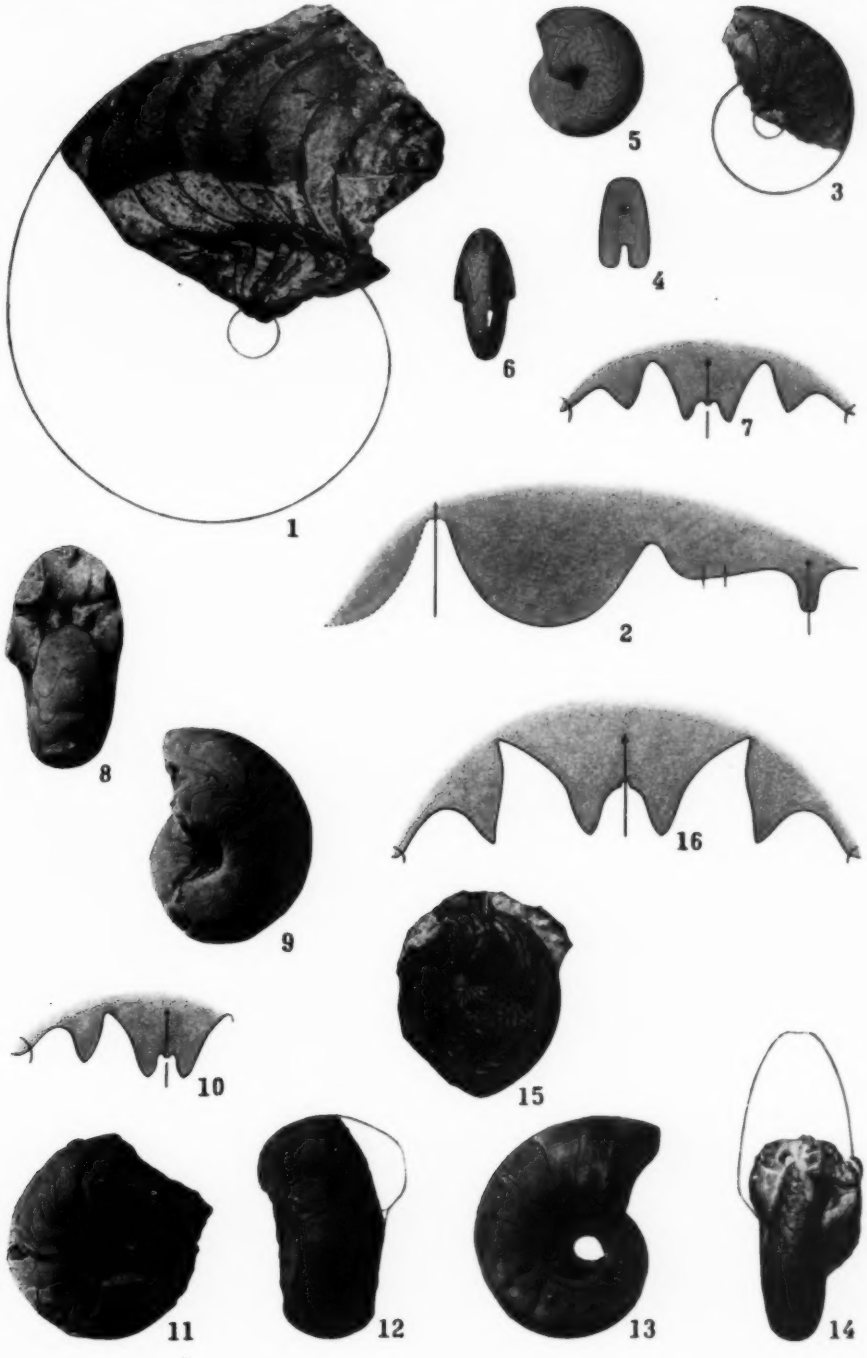
Figs. 1-4—*Stenopoceras tularosense,* A. K. Miller, n. sp. 1, 2. Lateral view and diagrammatic representation of a suture of holotype, × 1; 3, 4, lateral view and diagrammatic cross-section of penultimate whorl of same specimen as preceding, × 1.

5-7—*Milleroceras parrishi* (Miller and Gurley). Lateral and ventral views of holotype, × 1 (after Smith), and diagrammatic representation of a suture of same specimen, × 2.

8-11—*Milleroceras minusculum* A. K. Miller, n. sp. Ventral and lateral views and diagrammatic representation of an adoral suture of holotype, × 4, and lateral view of a slightly crushed paratype showing surface ornamentation of conch, × 4.

12, 13—*Endolobus schucherti* A. K. Miller, n. sp. Ventral and lateral views of holotype, × 1.

14-16—*Gurleyoceras discoidale* (Böse). Ventral and lateral views of the most nearly complete of the cotypes, × 1, and diagrammatic representation of a suture of same specimen, × 2.



Miller—Pennsylvanian cephalopods

Carboniferous of Texas and Kansas was designated as the genotype, and one other species *Nautilus rouillieri* De Koninck[14] of the Carboniferous of central Russia was referred to it.

At that time Hyatt discussed the genus briefly, contrasted it with *Phacoceras,* and referred it to the Koninckioceratidae. Since then it has been recognized in the Zittel-Eastman Textbook of Palaeontology and the Zittel-Broili Grundzüge der Paläontologie, but no additional representatives of it have been described, and nothing has been added to our knowledge of it.

The genus can be characterized briefly as follows: Form discoidal; conch rapidly expanded orad, strongly compressed, flattened laterally, and deeply involute. Venter is very narrow; in immature individuals it is flattened and is almost at right angles to the flat lateral sides of the conch, but in some species (not the genotype) the venter of mature specimens is angular. Whorls of immature representatives are therefore subrectangular in cross-section (impressed zone disregarded), whereas those of mature specimens are either subrectangular or subtriangular. Umbilicus small, umbilical shoulders rounded; umbilical walls broadly rounded but almost perpendicular to flat lateral sides of conch. Surface of internal mold smooth, and there are no longitudinal ridges on the lateral zones of the conch as there are in *Phacoceras,* but sinuous growth-lines are rather prominent; these curve strongly apicad as they approach the venter, indicating the presence of a deep hyponomic sinus.

The sutures also are sinuous. They are nearly straight or form only very shallow saddles as they cross the venter, but they bend abruptly apicad on the subangular ventro-lateral shoulders of the conch and form very broad rounded lobes as they cross the broad flat lateral sides of the conch. In mature specimens there is a reversal in the curvature of the sutures near the umbilicus and broad subangular or rounded saddles are formed; these appear on the umbilical shoulders during adolescence and gradually migrate ventrad as the conch nears maturity. In mature specimens the sutures are essentially straight and directly transverse on the umbilical wall and the dorsal two-thirds of the lateral sides of the impressed zone, but on the ventral one-third they curve apicad rather abruptly and form deep, moderately narrow, bluntly rounded lobes as they cross the ventral side of the impressed zone.

Very little information is available in regard to the internal structures of the conch, but the septa are only moderately convex apicad and the siphuncle of adolescent individuals, at least,

[14] The type of this species was originally described by Trautschold (*Die Kalkbrüche von Mjatschkowa;* Eine Monographie des oberen Bergkalks, erste Hälfte, pp. 28-29, pl. 3, fig. 7, 1874) and incorrectly referred to *Nautilus oxystomus* Phillips. De Koninck (*Faune du Calcaire Carbonifère de la Belgique,* première partie, p. 124, 1878) recognized this fact and proposed the name *"N. Rouillieri"* (not *"N. Rouilleri"* as stated by Tzwetaev and Hyatt) for the Russian form. The specimen described by Trautschold appears to be a mature individual; a small, immature representative showing the earlier stages of growth has since been described by Tzwetaev (*Mémoires du Comité Géologique,* vol. 5, no. 3, pp. 21, 53, pl. 6, figs. 33, 34, 1888).

is located slightly ventrad of the center of the conch, is very small, and is composed of cylindrical segments. It is apparently orthochoanitic in structure, but the only specimen available for study by the writer is so poorly preserved that septal necks and connecting rings cannot be differentiated.

The types of *S. dumbli,* the genotype, came from some unrecorded locality in Texas and from Fort Riley, Kansas; the only specimen figured came from the latter locality, presumably from the Fort Riley limestone, which is Early Permian in age. The type of *S. rouillieri* came from the Fusulina limestone of Miatschkowo, which is of Lower Pennsylvanian age; the same species has since been recognized elsewhere in central Russia, viz., in the Carboniferous limestone of the Matkosersky Canal and the Oölite of the village of Dewiatowo, on the Desna River, where its age is presumably the same as at Miatschkowo. The paleontological collections of the Nebraska Geological Survey contain an additional species, which came from one of the Lower Pennsylvanian limestones of Nebraska, and a fourth species is described below from the Pennsylvanian of New Mexico. The genus can therefore be said to range at least from Lower Pennsylvanian to Lower Permian, but apparently it is more abundant in the lower horizons.

STENOPOCERAS TULAROSENSE A. K. Miller n. sp.
Plate 12, figures 1-4

Form discoidal; conch rapidly expanded orad, strongly compressed, flattened laterally, and rather deeply involute. Nature of venter at maturity uncertain, but at adolescence it is strongly flattened (very slightly convex) and is approximately perpendicular to flat lateral sides of conch; ventro-lateral shoulders narrowly rounded. Lateral sides of conch are not quite straight but are very broadly rounded, and maximum width of conch is attained near mid-height of whorls. Depth of impressed zone equal to about one-fourth height of whorl. In adolescent part of the holotype, where height of whorl measures about 12 mm., maximum width measures about 7 mm.; width of venter about 3.5 mm.; and width at umbilical shoulders about 5.5 mm. Maximum width attained by preserved part of holotype, which is septate throughout and therefore represents only part of phragmacone, about 21 mm.; maximum width at umbilical shoulders, about 13 mm.

Umbilicus small and appears to become relatively smaller in the later stages of growth. Umbilical shoulders rounded. Umbilical wall broadly rounded but almost at right angles to flat lateral sides of conch. Surface of internal mold smooth and entirely devoid of markings other than sutures. Test thin and smooth.

Sutures sinuous; they are nearly straight as they cross the venter but curve slightly orad. They curve abruptly apicad on the subangular ventro-lateral part of the conch and form broad rounded lobes as they cross the broad flat lateral sides of the conch. At adolescence there is a subangular saddle on the umbilical shoulder; this saddle

gradually becomes less nearly angular and migrates ventrad as the conch nears maturity, and eventually it is located about one-fifth of the distance from the umbilicus to the venter. At maturity the sutures are essentially straight and directly transverse on the umbilical walls and the dorsal two-thirds of the lateral sides of the impressed zone, but on the ventral one-third they curve apicad rather abruptly and form deep, moderately narrow, bluntly rounded lobes as they cross the ventral side of the impressed zone.

Very little information is ascertainable in regard to the internal structures of the conch, but the septa are moderately convex apicad, and the siphuncle of adolescent individuals, at least, is only slightly ventrad of the center of the conch, is very small, and is composed of cylindrical segments. Where height of whorl measures 12 mm., siphuncle is about 4 mm., from ventral wall of conch (and therefore about 2 mm. ventrad of center of conch) and is slightly less than 1 mm. in diameter. The siphuncle is apparently orthochoanitic in structure, but the nature of the preservation of the holotype is such that septal necks and connecting rings can not be differentiated.

Remarks. The above description is based on a single incomplete specimen which apparently represents a small part of the outer whorl and almost half of the preceding one of a mature individual. The species can be differentiated from *S. dumbli* (Hyatt) by means of the narrowly, rather than broadly, rounded saddles of the external sutures just ventrad of the umbilicus. *S. rouillieri* (De Koninck) is a smaller, narrower form, and its venter is much narrower during adolescence and becomes angular at maturity.

Occurrence. Upper Pennsylvanian (Abo?) sandstone, one and one-fourth miles east of Tularosa, New Mexico.

Holotype. Peabody Museum of Natural History, Yale University, 13080.

Genus Milleroceras Hyatt

The genus *Milleroceras* was proposed by Hyatt in the Zittel-Eastman Text-book of Palaeontology (1900, p. 550) and although no diagnosis of it was given, *Goniatites parrishi* Miller and Gurley of the Pennsylvanian of Kansas City, Missouri, was designated as the genotype. Three years later, J. P. Smith in his well known monograph on the Carboniferous ammonoids of America (pp. 125, 127-128) questioned the validity of the genus and stated that he believed the type specimen to be "merely the young of some member of the Glyphioceratidae, probably either *Gonioloboceras* or *Dimorphoceras*"; in the 1913 edition of the Zittel-Eastman Text-book of Palaeontology he neglected to mention the genus, presumably considering it a synonym of *Gonioloboceras.* In 1915 Girty, in his report on the Wewoka fauna (U. S. Geol. Survey Bull. 544, pp. 261-262) followed Smith's suggestion and placed *Milleroceras* as a synonym of *Gonioloboceras.*

The type specimen of *Milleroceras parrishi,* the genotype, described below, is moderately small and the form of its conch and the shape of its

sutures, although similar to those of *Goniolobocerαs,* are distinctly more primitive; its conch is less strongly compressed laterally, and the lobes of its sutures are distinctly less acuminate and the saddles are narrowly rounded rather than sharply pointed. It is true that, as suggested by Smith, this specimen may be an immature representative of *Goniolobocerαs,* but, on the other hand, it may be a mature representative of the direct progenitor of that genus; the writer knows of no way to ascertain which of these two possibilities is the more probable. Furthermore, whether or not the specimen in question is a mature representative of the stock from which *Goniolobocerαs* developed, that group actually exists, and until it can be definitely shown (if that is possible) that the type of *M. parrishi* is an immature representative of some other genus, it will be best to retain it as the type of *Milleroceras,* and to regard that genus as intermediate between *Goniolobocerαs* and its Devonian or Mississippian progenitor.

From a study of the type alone the genus can be briefly diagnosed as follows: Form subdiscoidal; conch is rapidly expanded orad, slightly compressed laterally, and deeply involute. Whorls are strongly flattened laterally, narrowly rounded ventrally, and semielliptical in cross-section. Umbilicus small but deep; umbilical shoulders narrowly rounded; umbilical wall steep. The external suture consists of a broad ventral lobe and on either side of it two saddles and one lobe; there is an additional lobe on the umbilical wall. The ventral lobe is very broad, and it is divided by a short, broad median saddle; the two subdivisions of the ventral lobe are asymmetrical and obtusely pointed, and the median saddle is centrally notched by a small rounded tertiary lobe. The external saddle is almost as long as the ventral lobe, but it is narrower and is narrowly rounded orad; it is almost V-shaped but is distinctly asymmetrical and its ventral side is slightly concave whereas its dorsal is slightly convex. The first lateral lobe is short, broad, and obtusely pointed, and it also is asymmetrically V-shaped. The lateral saddle is broad, shallow, broadly rounded, and asymmetrical. The lobe on the umbilical wall is short, broad, and broadly rounded.

In so far as the writer has been able to ascertain, only *Goniatites limatus* Miller and Faber and possibly *Goniatites leviculus* Miller and Faber, both of the St. Louis group of Kentucky, and the form described below as *Milleroceras minusculum* A. K. Miller, n. sp., possess the same general characters as the type of *Milleroceras* and should be included in that genus. However, the forms described by Girty (Mo. Bur. Geol. and Mines, ser. 2, vol. 13, p. 364, 1915) and referred with question to *Milleroceras parrishi* may represent it; the nature of their sutures was not determined and therefore it is not possible to place them definitely in any genus.

When Hyatt proposed the genus *Milleroceras,* he placed it in the Primordialidae. In 1903, J. P. Smith removed it from that family and placed

it in the Aganididae along with *Goniolobocerας*, which he believed to have come from *Aganides* through *Münsteroceras*, but in 1913 he placed *Goniolobocerας* in the Primordialinae and did not mention *Milleroceras*. In 1915, Girty, apparently following Smith's earlier conclusions, placed

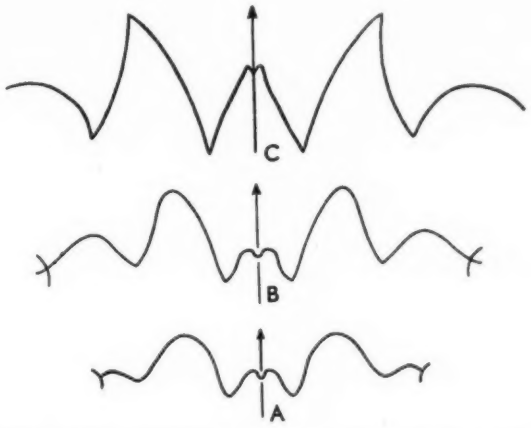


FIG. 1. Diagrammatic representations of external sutures of the genotypes of *Manticoceras* (A), *Milleroceras* (B), and *Goniolobocerας* (C). The first and last are ×1, the second ×3. The first is after Hall and the last after Meek.

Milleroceras, which he regarded as a synonym of *Goniolobocerας*, in the Aganididae. Böse (Am. Jour. Sci., ser. 4, vol. 49, p. 53, 1920) also believed that *Goniolobocerας* developed out of *Münsteroceras*.

It is true that the sutures of the more primitive members of *Milleroceras* and those of immature representatives of the more advanced ones do bear a certain resemblance to those of *Münsteroceras* of the Kinderhookian, but a comparison of their sutures with those of the type of that genus, *M. parallelum* (Hall), reveals certain striking dissimilarities, viz., the ventral lobe of the sutures in *M. parallelum* is distinctly longer and very much narrower and is contracted near midheight, the first lateral lobe is much larger, and the lateral saddle is far deeper and is strikingly different. On the other hand, the earlier sutures of *Milleroceras parrishi* are much more similar to those of the genotype of *Manticoceras*, *M. simulator* (Hall) of the Upper Devonian (Chemung) of New York, and the writer is convinced that *Milleroceras* developed out of the stock represented by that genus by the lengthening, narrowing, and sharpening of the subdivisions of the ventral lobe, the external saddle, and the first lateral lobe, and by the widening of the lateral saddle; a comparable development of the sutures is to be seen in *Dryochoceras* Morgan, which is distinguished chiefly by its active venter, and a further extension of the same line of development of the

sutures gave rise to *Goniolobocera*s (see text figure 1). The writer would therefore place all three of the Carboniferous genera *Milleroceras, Dryochoceras,* and *Goniolobocera*s in the Primordialidae.

MILLEROCERAS PARRISHI (Miller and Gurley)
Plate 12, figures 5-7

Goniatites sp.? KEYES, *1894,* Mo. Geol. Survey, vol. 5, pl. 56, fig. 1.
Goniatites parrishi MILLER AND GURLEY, *1896,* Ill. State Mus. Nat. Hist., Bull. 11, p. 36, pl. 4, figs. 6-8.
Milleroceras Parrishi HYATT, *1900,* Zittel-Eastman, Text-book of Palaeontology, ed. 1, vol. 1, p. 550.
Milleroceras parrishi SMITH, *1903,* U. S. Geol. Survey, Mon. 42, pp. 127-128, pl. 16, figs. 6-8.
*Goniolobocera*s *parrishi* GIRTY, *1915,* U. S. Geol. Survey, Bull. 544, pp. 261-262.
(?) *Goniolobocera*s *parrish?* GIRTY, *1915,* Mo. Bur. Geol. and Mines, ser. 2, vol. 13, p. 364.

Form subdiscoidal; conch is rapidly expanded orad, slightly compressed laterally, and deeply involute. Whorls are strongly flattened (being only very slightly curved) laterally and narrowly rounded ventrally; the lateral sides are inclined toward the ventral margin and whorls are semi-elliptical in cross-section. Maximum diameter of holotype, which is septate throughout and therefore represents only part of phragmacone, measures about 17 mm.; maximum height of whorl attained by preserved part of holotype, about 9.5 mm.; maximum width, which is attained just ventrad of umbilical shoulders, about 9 mm.; maximum depth of impressed zone, about 2.5 mm. (estimated). Near adapical end of visible part of outer whorl of holotype, height of whorl measures about 5 mm. and width about 6 mm.; it should perhaps be emphasized that in this part of the specimen the whorls are slightly wider than high, but the conch is expanded orad in a dorsoventral direction more rapidly than in a lateral one, and, as is obvious from the measurements given above, at the adoral end of the holotype the whorls are slightly higher than wide. Umbilicus small but deep, and maximum width attained by that of holotype measures about 2 mm. Umbilical shoulders narrowly rounded; umbilical wall broadly rounded but approximately perpendicular to nearly flat lateral sides of conch.

Surface of internal mold of visible part of holotype smooth and entirely devoid of markings other than the sutures. On adoral part of holotype each external suture consists of a broad ventral lobe and on each side of it two saddles and one lobe; there is an additional lobe on the umbilical wall. The ventral lobe is very broad and it is divided by a short, broad median saddle; the two subdivisions of the ventral lobe are asymmetrical and are obtusely pointed, and the median saddle is centrally notched by a small rounded tertiary lobe.[15] The external saddle is almost as long as the ventral lobe, but it is narrower and is narrowly rounded orad; it is almost V-shaped but is distinctly asymmetrical and its ventral side is slightly concave whereas its dorsal is slightly convex. The first lateral lobe is short, broad, and obtusely pointed, and it also is asymmetrically V-shaped. The lateral saddle

[15] This tertiary lobe was overlooked by Miller and Gurley, but it is very distinct on the specimen and was shown by Smith (pl. 16, fig. 8).

is broad, shallow, broadly rounded, and asymmetrical. The lobe on the umbilical wall is short, broad, and broadly rounded. The internal suture is not visible.

Remarks. As early as 1894, Keyes (see synonomy) figured a specimen which apparently is conspecific with the above described genotype, but he refrained from naming it, presumably because he did not know the exact horizon or the locality from which it came. The writer has not examined that specimen, but as nearly as can be told from the published figure, it differs from the specimen under consideration only in that it is considerably larger. It is stated to have come from the "Carboniferous, Upper Coal Measures" and to be in the Hare Collection, but the locality from which it came is not indicated.

In 1915, Girty briefly described some very small goniatites from the Fort Scott member of the Henrietta formation of Missouri and referred them with question to this species. The reference however is stated to be based "entirely on the strength of a certain external resemblance, for the suture and consequently the generic position are unknown." In view of the fact that they came from a much lower horizon than the type of this species, it seems extremely doubtful if they are conspecific with it, and since the nature of their sutures was not determined there is no good reason to believe that they are even congeneric.

The genotype is an internal mold that is exceedingly well preserved in limestone, but unfortunately it is not complete adorally and therefore nothing is known in regard to the living chamber. This species is easily distinguished from the two described species that the writer is tentatively placing in this genus, *Goniatites leviculus* Miller and Faber and *Goniatites limatus* Miller and Faber, by means of its smaller umbilicus and less strongly compressed conch as well as certain obvious differences in the sutures; both of those species are known to occur only in the St. Louis group of Crab Orchard, Kentucky. *Milleroceras minusculum* A. K. Miller, n. sp., described below, is a much smaller form and at least during adolescence its whorls are marked by prominent sinuous transverse constrictions, which may or may not be present also on the earlier volutions of the species under consideration.

Occurrence. Kansas City formation, Kansas City, Missouri.

Holotype. Gurley Collection, Walker Museum of Paleontology, The University of Chicago, 6209.

MILLEROCERAS MINUSCULUM A. K. Miller, n. sp.

Plate 12, figures 8, 11

Gonioloboceras discoidale [part] BÖSE, *1920*, Am. Jour. Sci., ser. 4, vol. 49, pp. 52-54.

Conch rather small; form subdiscoidal; conch is rapidly expanded orad and deeply involute; and whorls are flattened laterally, rather narrowly rounded ventrally, and semi-elliptical in cross-section (impressed zone disregarded). Maximum diameter of holotype, which represents only part of the phragmacone, measures about 7.5 mm.; maximum height of whorl

measures about 4 mm.; maximum width of whorl, which is attained just ventrad of the umbilical shoulders, about 4 mm.; maximum depth of impressed zone, about 1.5 mm. At adapical end of outer whorl of holotype, height of whorl measures about 1.75 mm. whereas width measures slightly less than 2 mm.; at adoral end of largest paratype, which attains a maximum diameter of about 10 mm., height of whorl measures about 6 mm., width about 5.5 mm., and depth of impressed zone about 2 mm. These measurements, taken together with the fact that at the adapical end of the outer whorl of the holotype the whorls are almost evenly rounded laterally and therefore approach semicircularity in cross-section, make it obvious that in its earlier stages of development the conch is subglobose, but whorls expand more rapidly in a dorso-ventral direction than in a lateral one and therefore become flattened laterally and conch becomes subdiscoidal. Umbilicus small and maximum diameter attained by that of holotype measures about 1.5 mm. Umbilical shoulders so abrupt as to appear almost subangular. Umbilical wall only slightly curved and inclined to nearly flat lateral sides of conch at an angle varying from almost 90 degrees at adapical end of outer whorl of holotype to about 45 degrees at adoral end of largest specimen available for study.

Test thin and marked by numerous prominent sinuous growth-lines. These form broad, shallow, rounded lobes as they cross the lateral zones of the conch, similar rounded saddles on the ventro-lateral zones, and slightly deeper and narrower rounded lobes on the ventral zone; faint impressions of them are discernible on the internal mold of the conch. Earlier volutions of conch marked also by broad, prominent, rounded sinuous constrictions. There are four (or five) of these to the volution. They are nearly straight along the lateral and ventro-lateral sides of the conch but form very broad, shallow lateral lobes and ventro-lateral saddles, and they form distinct lobes as they cross the narrowly rounded ventral part of the conch. They become less prominent adorally, and on the adoral part of the largest specimen available for study (which has a maximum diameter of only 10 mm.), they are very faint and not easily discerned; Böse failed to detect them.

Each external suture consists of a broad ventral lobe and on either side of it two saddles and one lobe; there is in addition a lobe on the umbilical wall. The ventral lobe is broad and short, and it is divided by a short, broad (almost as wide as long), straight-sided, U-shaped median saddle, which is about one-third as long as the ventral lobe and is centrally notched by a small rounded tertiary lobe. The two subdivisions of the ventral lobe are slightly narrower than the intermediate saddle and like it are symmetrical, but they are obtusely pointed. The external saddle is almost as long as the ventral lobe, but it is somewhat narrower and is narrowly rounded orad; it is almost V-shaped but it very asymmetrical and its

ventral side is concave whereas its dorsal is slightly convex. The first lateral lobe is short, broad, and obtusely pointed, and it also is asymmetrically V-shaped. The lateral saddle is broad, moderately deep, broadly rounded, and asymmetrical. The lobe on the umbilical wall is broad, shallow, and broadly rounded. The exact shape of the internal suture can not be determined, but it consists of a long, narrow dorsal lobe and on each side of it a long, narrow, rounded, U-shaped saddle, a shorter, wider lateral lobe, and a very broad, shallow, broadly rounded lateral saddle.

In the adapical part of the outer whorl of the holotype, the sutures are distinctly more primitive than those described above. The ventral lobe is relatively shorter and the median saddle that divides it is very much smaller, though it is still centrally notched; the subdivisions of the ventral lobe are narrowly rounded rather than pointed. The external saddle is shorter and broader and less narrowly rounded. The lateral lobe also is shorter and broader and is rounded. The lateral saddle is deeper but not as wide. In this part of the conch the suture is strikingly similar to that of *Manticoceras* of the Upper Devonian; Böse compared it to that of *Münsteroceras* of the Kinderhookian, but at least in the type species of that genus the ventral lobe of the sutures is distinctly longer and very much narrower and is contracted near mid-height, the first lateral lobe is much larger, and the lateral saddle is deeper.

Remarks. The above description is based largely on four specimens but seventeen other less well preserved ones are available for comparisons. Böse regarded these specimens as immature representatives of *Gurleyoceras* [*Goniolobocerasl discoidale,* and he segregated the four specimens mentioned above and labelled them "type specimens (4); young individuals"; two much larger specimens were also separated and labelled "type specimens (2); adult." It is possible that these small individuals may be immature representatives of the larger form, and the fact that there is a fairly rapid development of their sutures even on the outermost whorl might be taken to mean that they are immature. Nevertheless, since the collection contains twenty-one small specimens with a diameter of 10 mm. or slightly less, nine or ten large specimens with a diameter of 25 mm. or more, and no intermediate forms, it seems probable that these small specimens actually represent a mature form which was much smaller than typical *G. discoidale* and had much simpler sutures. If, as is now believed, this interpretation is correct, these specimens should not be referred to the same genus as *G. discoidale* but should be regarded as representing the stock out of which it and related forms arose. The general shape of the conch and the nature of the sutures indicate a relationship to *Milleroceras,* to which genus the species is accordingly referred. Its small size and narrow umbilicus serve to distinguish it from the three other known representatives of that genus; furthermore, sinuous transverse constrictions

and growth-lines are not known to occur on the earlier whorls of any of those species, though they may be present.

Occurrence. Upper Pennsylvanian (Abo?) sandstone, one and one-fourth miles east of Tularosa, New Mexico.

Types. Peabody Museum of Natural History, Yale University, 13081 (holotype), 13082 and 13083 (paratypes).

Genus GURLEYOCERAS A. K. Miller, n. gen.

As has been noted by both Girty and Böse, one group of the species that have been referred to *Goniolobocerας* differ from the type of that genus, *G. goniolobum* (Meek), in that at maturity the venter is marked by a distinct longitudinal furrow and is therefore retuse, the conch is less deeply involute, and the sutures present certain significant differences in that the lobes and saddles are less acuminate, the median saddle in the ventral lobe is much wider at its adoral end, and the ventral side of the first lateral lobe is sigmoidal rather than evenly convex. These differences seem to the writer to be of generic significance, and the name *Gurleyoceras,* given in honor of Wm. F. E. Gurley, is here proposed for this group and *Goniolobocerας welleri* Smith of the Graham formation of the Cisco of Texas (holotype) and the Pennsylvanian of Montgomery County, Illinois, and possibly the Wewoka formation of Oklahoma, is designated as the genotype. That species has been ably described and illustrated by J. P. Smith in his monograph on the Carboniferous ammonoids of America (pp. 125-126, pl. 20, figs. 9-11; pl. 21, figs. 1-6). In addition to the genotype the following species apparently should be referred to this genus *Goniolobocerας gracile* (Girty)[16] of the Wewoka and possibly the Wetumka formations of Oklahoma, *Goniolobocerας discoidale* (Böse) of the Upper Pennsylvanian (Abo?) of New Mexico, and possibly *Goniatites hathawayanus* McChesney of the Cherokee of Illinois. As far as is now known the genus is confined to the Pennsylvanian of North America, but it apparently is widespread in the Middlewest and Southwest, where it ranges throughout most of the Pennsylvanian system.

The genus can be briefly diagnosed as follows: Form subdiscoidal, and conch is rapidly expanded, strongly compressed, flattened laterally, and rather deeply involute; the venter is narrowly rounded during adolescence but is marked by a narrow longitudinal furrow at maturity. Umbilicus narrow and very little of inner whorls is exposed; umbilical shoulders rounded. Surface of conch smooth at maturity and devoid of markings other than sutures, but during early adolescence sinuous transverse constrictions are present in at least some species. In mature specimens each external suture consists of a broad ventral lobe and on

[16] This form was described by Girty (New York Acad. Sci. Annals, vol. 21, pp. 153-154, 1911: *U. S. Geol. Survey,* Bull. 544, pp. 263-264, 1915) as a variety of *Goniolobocerας welleri* Smith, but in the writer's opinion it is specifically distinct from that form. In his generic discussion Girty (op. cit., pp. 261-263, 1915) refers to *"G. welleri* var. *wewokanum"* but does not mention *G. welleri* var. *gracile,* whereas in his specific description the reverse is the case; presumably the former should be regarded as a synonym of the latter.

each side of it two saddles and one lobe; there is also an additional lobe on the umbilical seam or on the umbilical wall. The ventral lobe is short and broad and is divided by a broad, deep, U-shaped median saddle; the subdivisions of the ventral lobe are subangular or pointed, and the median saddle is typically divided centrally by a small rounded tertiary saddle, but in one species that is being referred to this genus it is divided by a small tertiary lobe. The external saddle is subangular or obtusely pointed and is asymmetrically V-shaped; its ventral side is cancave whereas its dorsal is sigmoidal. The lateral lobe is narrowly rounded, subangular, or obtusely pointed, and it also is asymmetrical. The lateral saddle is broad and rounded. The lobe on the umbilical seam or wall is broad and shallow. The internal suture consists of a small, narrow, rounded dorsal lobe and on each side of it a small, slightly wider, U-shaped saddle, a small, more or less V-shaped lobe, and a very broad, shallow, rounded lateral saddle, which extends to the lobe on the umbilical seam or wall.

The general shape of the conch and the sutures of this genus clearly indicate that it developed out of the stock represented by *Milleroceras,* and it should therefore be placed in the Primordialidae and associated with that genus and *Dryochoceras* Morgan and *Goniolobocerαs* Hyatt. *Milleroceras* seems to be the most primitive member of this group of Carboniferous genera, and it apparently represents the stock that gave rise to the others.

The characters that serve to distinguish *Gurleyoceras* from *Goniolobocerαs* are discussed above. In *Milleroceras* the venter is narrowly rounded and is not marked by a longitudinal furrow, and the ventral side of the lateral lobes of the sutures are not sigmoidal; in *Dryochoceras* the venter is acute rather than retuse.

GURLEYOCERAS DISCOIDALE (Böse)
Plate 12, figures 14-16

Goniolobocerαs discoidale [part] BÖSE, *1920,* Am. Jour. Sci., ser. 4, vol. 49, pp. 52-54.

Form subdiscoidal; conch rapidly expanded orad, strongly compressed, flattened laterally and deeply involute; the nearly flat lateral sides of the conch are inclined toward the ventral margin and the whorls are narrowly subovoid in cross-section. During adolescence the venter is narrowly rounded, but at maturity a narrow, shallow longitudinal furrow develops along the venter; this furrow is visible on only one of the type specimens, which is a fragment representing part of the outer whorl of a large individual; the portion of the whorl represented is approximately 25 mm. high and 15 mm. wide, and the longitudinal furrow is just beginning to develop; it gradually increases in prominence adorally, and, as the collection being studied contains fragments of this species that appear to represent much larger individuals, the furrow probably becomes quite prominent during late maturity. In the figured cotype, where maximum diameter of specimen measures about 27.5 mm. (estimated), maximum height of whorl measures about 15 mm., maximum width, which is attained just ventrad of umbilical

shoulders, measures about 10 mm., and whorls appear to be impressed to about one-third their height by preceding volution.

Umbilicus very narrow and very little of inner whorls is exposed. Umbilical shoulders broadly rounded, and in adapical part of outer whorl of figured cotype, the lateral sides of the conch curve gradually in to the umbilical seam. In the adoral part of that specimen a distinct umbilical wall develops; it is essentially perpendicular to the lateral sides of the conch, but its junction with them is rounded.

Surface of internal mold of visible part of figured cotype smooth and entirely devoid of markings other than the sutures. On adoral part of that specimen each external suture consists of a broad ventral lobe and on each side of it two saddles and one lobe; there is also an additional lobe on the umbilical wall. The ventral lobe is short and broad, and it is divided by a broad, deep, U-shaped median saddle which is about half as long as the ventral lobe and is slightly wider than long; the subdivisions of the ventral lobe are much smaller than the intermediate saddle and are obtusely pointed, but they are symmetrical or very nearly so. The median saddle is divided centrally by a small, rounded, U-shaped tertiary saddle. The external saddle is as long as the ventral lobe but is narrower; it is subangular and is very asymmetrically V-shaped; its ventral side is rather strongly concave whereas its dorsal is distinctly sigmoidal. The lateral lobe also is asymmetrical; it is obtusely pointed and its dorsal side is slightly convex. The lateral saddle is broad, moderately shallow, and rounded. The lobe on the umbilical seam is broad, shallow, and subangular; in the adapical part of the outer whorl of the figured cotype this lobe is located on the umbilical seam, but in the adoral part of that whorl a distinct umbilical wall is developed and the lobe under consideration gradually loses its angularity and migates ventrad, so that it is located near the center of the umbilical wall. The exact shape of the internal suture can not be discerned, but it consists of a small, narrow dorsal lobe and on each side of it a small, shorter, broader, narrowly rounded dorsolateral saddle, a shorter V-shaped lateral lobe, and a very broad rounded lateral saddle that extends to the lobe on the umbilical wall.

A small break near the adapical end of the outer whorl of the figured specimen exposes the siphuncle. It is nearly but not quite in contact with the ventral wall of the conch, cylindrical in shape, and about .5 mm. in diameter.

Remarks. The above description is based entirely on the figured cotype and another large fragmentary one, but eight or nine additional, less nearly complete specimens are available for comparisons; most of these represent such a small portion of the conch that little significant information can be gleaned from them. However, it is probably worth recording that in one of them, which represents a moderately large individual with a distinctly flattened venter, there are small asymmetrical tertiary lobes on each side of the ventral tertiary saddle.

This species appears to be much more closely related to *Gurleyoceras welleri* (Smith) than to any other

known species; it differs from that form in that the ventral furrow is much less distinct, the whorls appear to be relatively lower and wider, and the sutures are not precisely similar in that the subdivisions of the ventral lobe are much wider, symmetrical, and obtusely pointed, rather than asymmetrical and acuminate; and the ventral side of the lateral lobe is less strongly sigmoidal. In *Gurleyoceras gracile* (Girty) the ventral zone is much narrower, the ventral furrow is much deeper and more prominent, the primary lobes and saddles appear to be narrowly rounded rather than obtusely pointed or subangular, and the secondary ventral saddle is divided centrally by a tertiary lobe rather than a tertiary saddle. The only published illustration and descriptions of *Goniatites hathawayanus* McChesney leave much to be desired, but because of the very large umbilicus and the relatively low, broad whorls of that species, it is extremely doubtful if it belongs in even the same genus as the above described form.

Occurrence. Upper Pennsylvanian (Abo?) sandstone, one and one-fourth miles east of Tularosa, New Mexico.

Cotypes. Peabody Museum of Natural History, Yale University, 13084.

Genus WIEDEYOCERAS A. K. Miller n. gen.

Recently Wiedey[17] described a new species of Carboniferous goniatites from the Lower Pennsylvanian (presumably the Cherokee) of Iowa, and although he recognized that it "seemingly cannot now be assigned to any genus without some reserve," he referred it together with a number of European Mississippian forms to *Eumorphoceras* Girty, as he believed that the available evidence was insufficient to justify the erection of a new generic name. The sutures of Wiedey's species, *Eumorphoceras sanctijohanis,* are superficially similar to those of *Eumorphoceras bisulcatum* Girty, the genotype of *Eumorphoceras,* but, as is explained below, they present certain significant differences, and the surface ornamentation of the conchs of the two forms is so strikingly different that there seems to be little reason to regard them as congeneric. Also, the collection being studied by the writer contains representatives of two species that apparently are congeneric with *Eumorphoceras sanctijohanis,* and the generic name *Wiedeyoceras* is therefore proposed for these three species and *E. sanctijohanis* is designated as the genotype. The European Mississippian species listed by Wiedey as being congeneric with *E. sanctijohanis,* are not regarded by the writer as belonging in the new genus; in his opinion they represent several genera but not *Eumorphoceras* or *Wiedeyoceras.*

The new genus *Wiedeyoceras* can be briefly characterized as follows: Form subdiscoidal to subglobose; conch is moderately expanded orad and deeply involute but is typically only slightly compressed and in one species is very slightly depressed. Whorls are flattened laterally, rounded ventrally, and impressed dorsally. Umbilicus moderately small; umbilical shoulders abrupt; umbilical wall steep.

[17] Wiedey, L. W., A new species of an exotic group of Carboniferous goniatites: *Am. Jour. Sci.,* ser. 5, vol. 17, pp. 321-325, 1929.

Surface of conch marked by sinuous growth-lines which curve rather strongly apicad as they cross the venter due to the presence of a moderately deep hyponomic sinus; also sinuous transverse constrictions are present on small and immature individuals, and in one small form that is being referred to this genus rather prominent ribs or elongated nodes are present on the umbilical border. At maturity each external suture consists of a moderately broad ventral lobe and on each side of it two saddles and one lobe; there is also an additional lobe on the umbilical wall. The ventral lobe is divided by a rather prominent median saddle, which in turn is divided centrally by a small tertiary lobe; all of the subdivisions of the ventral lobe are angular or nearly so. The external saddle is narrower than the ventral lobe and, as it is rounded orad and is more or less straight-sided, is depressed-U-shaped. The first lateral lobe is similar in shape to the external saddle but is shorter and narrower. The lateral saddle is broad, broadly rounded, and asymmetrical. The lobe on the umbilical shoulder is broad, shallow, and broadly rounded. With the exception of the ventral lobe, all of the primary lobes and saddles are rounded and undivided; this fact serves to distinguish members of this genus from those of most similar genera.

The sutures of this genus are somewhat similar to those of *Eumorphoceras*, but the ventral lobe is narrower and its lateral subdivisions are pointed rather than rounded; also the lateral lobe is narrower and the lateral saddle is broader. Furthermore, the presence in *Eumorphoceras* of lateral ribs and particularly the presence of longitudinal furrows between the lateral and the ventral zones of the conch serve to differentiate that genus from the one under consideration. Wiedey compared the adolescent stages of his species to *Münsteroceras* of the Kinderhookian, but in that genus the ventral lobe is much narrower and is distinctly contracted near mid-height and the lateral lobes are pointed rather than rounded. Nevertheless, a suture of a specimen in the adolescent stage of development shown by Wiedey (p. 324, fig. 5) demonstrates clearly that this genus developed out of one of the more primitive members of the Glyphioceratidae and that it should therefore be referred to that family and not to the Primordialidae, which also is represented in the Carboniferous by forms that superficially appear to be strikingly similar to the one under consideration.

WIEDEYOCERAS NODOMARGINATUM
A. K. Miller, n. sp.
Plate 13, figures 6-8

Goniolobоceras ? sp. [part] BÖSE, *1920*, Am. Jour. Sci., ser. 4, vol. 49, p. 58.

Form subglobose; conch moderately expanded orad, very slightly depressed dorso-ventrally, and deeply involute. Whorls are flattened laterally but are broadly rounded ventro-laterally and ventrally and are broadly semi-elliptical in cross-section. Maximum diameter of figured cotype measures about 6 mm.; maximum height of whorl, almost 3 mm.; maximum width of whorl, which is attained just ventrad

of umbilical shoulders, about 3 mm.; and whorls are impressed to about two-fifths their height by preceding volution. One of the cotypes attains a maximum diameter of nearly 12 mm., but it is very poorly preserved and appears to have been somewhat crushed and distorted during preservation. Umbilicus small and maximum diameter of that of figured cotype measures only about 1.5 mm. Umbilical shoulders so abrupt as to appear almost subangular; umbilical wall almost perpendicular to flattened lateral sides of conch.

Test thin and marked by numerous, fine sinuous growth-lines; these curve apicad as they cross the lateral zones of the conch, orad as they cross the ventro-lateral, and apicad again as they cross the ventral. They are not very prominent on the test and are only locally discernible on the internal mold. Each volution of internal mold is marked also by three prominent rounded sinuous constrictions; they are almost parallel to the growth-lines but their flextures are not as great. The umbilical borders of the earlier volutions are marked by a single row of very distinct short ribs or transversely elongated nodes; these are very prominent on the umbilical shoulders, but they die out rapidly toward the venter and are not discernible beyond the middle of the lateral sides of the conch. There are ten or twelve of them to the volution, and they decrease in prominence adorally and are not perceivable on the extreme adoral portion of the figured cotype.

Each external suture consists of a moderately broad ventral lobe and on each side of it two saddles and one lobe; there is also an additional lobe on the umbilical wall. The ventral lobe is divided by a median saddle which is only about one-fifth as deep as the lobe is long and is divided centrally by a small tertiary lobe; the secondary saddles and the secondary and tertiary lobes are so narrowly rounded as to appear subangular. The external saddle is only slightly narrower than the ventral lobe and is broadly rounded. The first lateral lobe is similar in shape to the external saddle but is shorter, narrower, and somewhat more narrowly rounded. The lateral saddle is narrower than the external one, is much shallower and much more broadly rounded, and is asymmetrical. The lobe on the umbilical shoulder is very broad, shallow, and broadly rounded. The internal suture is not visible on any of the types.

Remarks. The above description is based on nine cotypes; eight of them are of about the same size as the one figured (or only slightly smaller), but the other is distinctly larger and attains a maximum diameter of nearly 12 mm. All possess the same general characters and aside from size no appreciable variation is shown. Böse grouped three of these cotypes together with a specimen that the writer is describing as *Wiedeyoceras lineolatum* n. sp., and his brief description is based on all four specimens; therefore it does not agree with either of the specific descriptions given in this report but partakes of both.

This species is easily distinguished

from the other two known representatives of the genus by its small size, umbilical nodes, and depressed rather than compressed conch; also in *W. lineolatum* there are five transverse constrictions to the volution whereas in this species there are only three.

Occurrence, Upper Pennsylvanian (Abo?) sandstone, one and one-fourth miles east of Tularosa, New Mexico.

Cotypes. Peabody Museum of Natural History, Yale University, 13085.

WIEDEYOCERAS LINEOLATUM A. K. Miller, n. sp.

Plate 13, figures 3-5

Goniolobоceras ? sp. [part] BÖSE, *1920,* Am. Jour. Sci., ser. 4, vol. 49, p. 58.

Form subdiscoidal; conch is expanded orad, somewhat compressed, and deeply involute, and whorls are strongly flattened laterally and narrowly rounded ventrally. Maximum diameter of holotype measures about 8 mm.; maximum width of whorl, which is attained just ventrad of umbilical shoulders, about 3.5 mm.; maximum height of whorl, about 4 mm.; and maximum depth of impressed zone, about 1.5 mm. Umbilicus moderately small but deep and umbilical shoulders of all volutions are visible; maximum diameter of umbilicus of holotype measures about 2.25 mm.; maximum depth about 1.5 mm. Umbilical shoulders abrupt and almost subangular. Umbilical wall steep and nearly straight; it is slightly convex and is inclined to the flattened lateral side of the conch at some 75 degrees.

Test thin and marked by numerous, fine sinuous growth-lines which curve slightly apicad as they cross the broad flat lateral sides of the conch, more strongly orad as they cross the ventrolateral zones, and still more strongly apicad as they cross the narrow ventral zone; they indicate the presence of a moderately deep, rounded

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EXPLANATION OF PLATE 13

All specimens figured are from Upper Pennsylvanian (Abo?) sandstone, 1¼ miles east of Tularosa, New Mexico.

FIGS. 1, 2—*Gastrioceras paucireticulatum* A. K. Miller, n. sp. Lateral and ventral views of the holotype, ×4.

3-5—*Wiedeyoceras lineolatum* A. K. Miller, n. sp. Ventral and lateral views and diagrammatic representation of a suture of holotype, ×4.

6-8—*Wiedeyoceras nodomarginatum* A. K. Miller, n. sp. Lateral and ventral views and diagrammatic representation of a suture of a cotype, ×4.

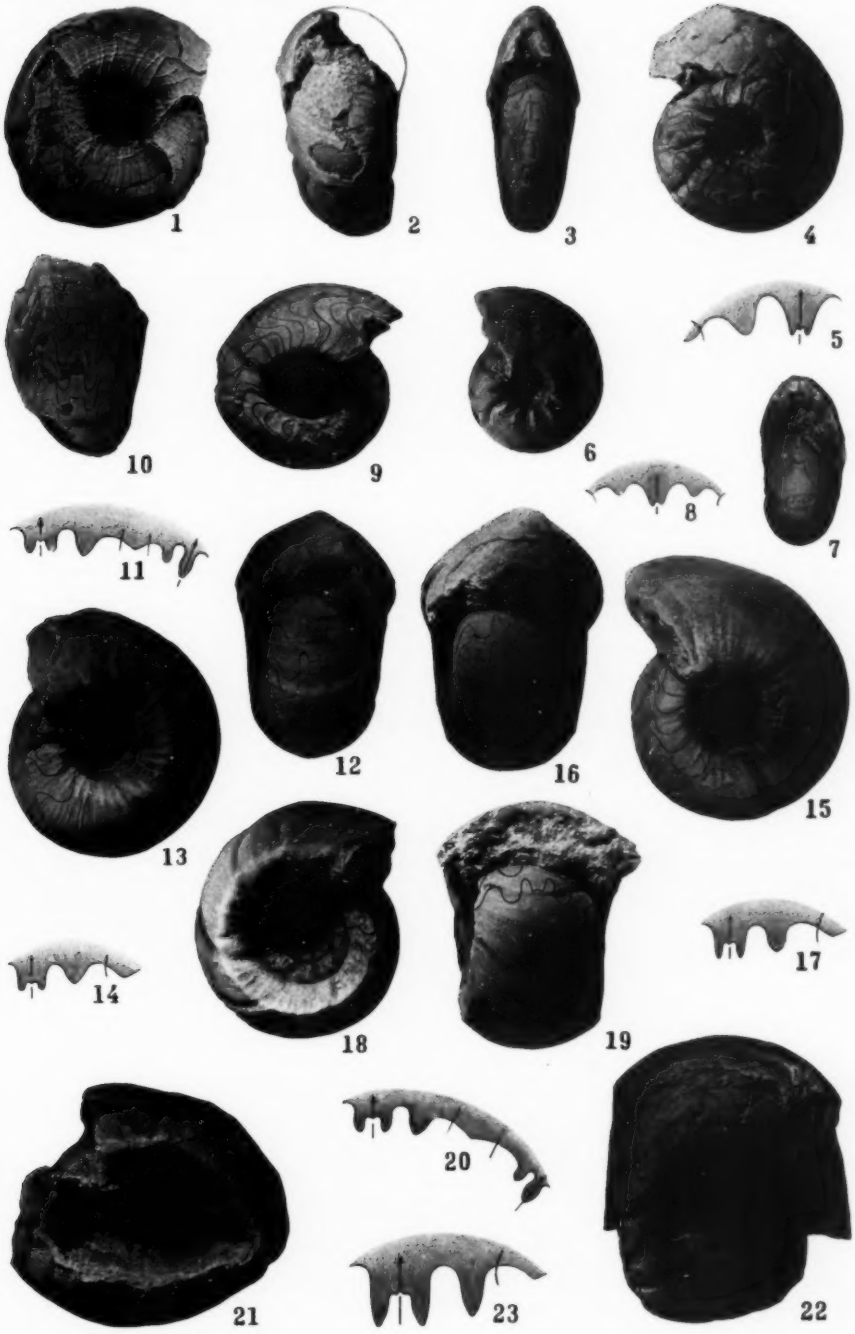
9-11—*Gastrioceras multiseptum* A. K. Miller, n. sp. Lateral and ventral views of holotype, which is somewhat crushed, and diagrammatic representation of a suture of paratype, ×4.

12-14—*Gastrioceras drakei* A. K. Miller, n. sp. Ventral and lateral views and diagrammatic representation of a suture of holotype, ×4.

15-17—*Gastrioceras bakeri* A. K. Miller, n. sp. Lateral and ventral views and diagrammatic representation of a suture of holotype, ×4.

18-20—*Gastrioceras subtilicostatum* Böse. Lateral and ventral views of a cotype which is in a late adolescent stage of development, ×4, and diagrammatic representation of a suture of a similar cotype, ×4.

21-23—*Gastrioceras angusticameratum* A. K. Miller, n. sp. Lateral and ventral views and diagrammatic representation of a suture of holotype, which was crushed and greatly distorted during preservation, ×4.



Miller—Pennsylvanian cephalopods

hyponomic sinus. They are rather prominent on the exterior of the test and are very distinct on the internal mold; they appear to be much more strongly developed on the umbilical shoulders of the inner whorls than on those of the outer. Outer volution of holotype is marked also by five prominent, rounded transverse constrictions, which are nearly straight but curve very slightly apicad on the lateral and ventral zones of the specimen.

Each external suture consists of a moderately broad ventral lobe and on each side of it two saddles and one lobe; there is also an additional lobe on the umbilical wall. The ventral lobe is moderately long and is divided by a median saddle which is about one-fifth as deep as the lobe is long and is divided centrally by a small tertiary lobe; the secondary saddles and the secondary and tertiary lobes are all angular or nearly so. The external saddle is only slightly narrower than the ventral lobe and is broadly rounded. The first lateral lobe is similar in shape to the external saddle but is shorter, narrower, and somewhat more narrowly rounded. The lateral saddle is wider than the external one, and is much shallower and much more broadly rounded. The lobe on the umbilical shoulder is broad, shallow, and broadly rounded. The internal suture is not visible on the holotype and only known representative of the species.

Remarks. The above description is based on a single specimen which is an internal mold to which fragments of the test adhere. It is moderately well preserved in limonite, but it appears to have been slightly crushed laterally during preservation, and as it is septate throughout, it represents only part of the phragmacone. The species is easily distinguished from *W. sanctijohanis* by its small size, prominent growth-lines, large umbilicus, and relatively long ventral lobe in which the median saddle is relatively small. The conch of *W. nodomarginatum* is more nearly globose and is depressed dorso-ventrally rather than compressed laterally, its whorls are marked by three rather than five transverse constrictions, and it bears a row of rather prominent nodes on its umbilical border.

Occurrence. Upper Pennsylvanian (Abo?) sandstone, one and one-fourth miles east of Tularosa, New Mexico.

Holotype. Peabody Museum of Natural History, Yale University, 13086.

Genus GASTRIOCERAS Hyatt

GASTRIOCERAS SUBTILICOSTATUM Böse

Plate 13, figures 18-20

Gastrioceras subtilicostatum BÖSE, *1920*, Am. Jour. Sci., ser. 4, vol. 49, pp. 54-56.

Form subglobose; conch is expanded orad moderately rapidly, strongly depressed dorso-ventrally, and slightly involute; whorls are very broadly rounded ventrally, subangular ventro-laterally, slightly convex laterally, distinctly impressed dorsally, and subtrapezoidal in cross-section. Height of whorl equal to almost half maximum width, which is attained at subangular umbilical shoulders, and depth of impressed zone equal to about one-third height of whorl. Umbilicus large, deep, and funnel-shaped, and umbilical

shoulders of all volutions are exposed; width of umbilicus equal to about two-thirds diameter of specimen, and umbilicus is almost half as deep as wide. Umbilical shoulders subangular. Umbilical wall nearly straight (slightly convex) and inclined to dorso-ventral plane of conch at some 45 degrees. Maximum diameter attained by figured cotype, which apparently is in a late adolescent stage of development, measures almost 9 mm.; maximum width, about 7 mm.; maximum height of whorl, about 3 mm.; maximum depth of impressed zone, about 1 mm.; and maximum width and depth of umbilicus, about 6 mm. and 2.75 mm., respectively. Some of the fragmentary cotypes represent much larger individuals than the figured specimen and show that in this species the whorls attained a height of at least 9 mm. and a maximum width of at least 16 mm.; the whorls of these large individuals, like those of the smaller ones, are impressed to about one-third their height by the preceding volution.

Each volution of conch is marked by five to seven (the number increasing in the later volutions) prominent, rounded, sinuous transverse constrictions. These curve slightly apicad as they cross the umbilical wall and the ventro-lateral zones of the conch, but they form broad, deep, rounded saddles as they cross the ventral zones; they are essentially parallel to the growth-lines.

On the umbilical wall of each volution of immature individuals there are about thirty rather prominent transverse ribs or costae. These die out dorsally and do not reach the umbilical seam; the dorsal side of the conch is marked only by numerous, fine transverse growth-lines, which however are very distinct. The costae of the umbilical walls swell into small but very distinct nodes on the umbilical shoulders, and from each of these nodes one or two clusters of two to four fine lines continue across the broadly rounded ventral part of the conch; these curve rather strongly orad and are essentially parallel to the transverse sinuous constrictions. This ornamentation is very prominent on the internal mold as well as on the test. It is relatively coarse and is very conspicuous in immature individuals, but it gradually becomes less prominent with the development of the conch. On the largest individuals represented in the collection, the small costae on the umbilical wall are numerous but not very prominent and are indistinct on the internal mold; the nodes on the umbilical shoulders are farther apart and less distinct, and the sinuous growth-lines do not become fasciculate as they approach the nodes, but continue across them uninterruptedly. On these large individuals there are two or three rather prominent longitudinal lirae on the umbilical shoulders, and where these cross the transverse growth-lines, small tubercles are formed; these longitudinal lirae are present also on the small individuals but they are so faint that were it not for the prominence attained by them on the later volutions, they would probably have been overlooked. Very little of this ornamentation is

discernible on the internal molds of the large individuals.

The external suture consists of a moderately broad ventral lobe and on each side of it two saddles and one lobe; the second saddle is on the subangular umbilical shoulder, and it is followed by a lobe on the umbilical wall. The ventral lobe is short and broad (nearly as long as wide), and its sides are almost straight and essentially parallel; it is divided by a large, broad median saddle which is slightly more than half as deep as the lobe is long and is straight-sided and U-shaped but is divided centrally by a small rounded tertiary lobe. The two lateral subdivisions of the ventral lobe are narrower than the intermediate saddle, almost straight-sided, and subangular. The external saddle is as long as the ventral lobe but is much narrower, almost straight-sided, rounded, and therefore U-shaped. The lateral lobe is almost as long as the external saddle and during adolescence is similar to it in shape, but it is obtusely pointed in mature individuals. The saddle on the umbilical shoulder is broad, shallow, and broadly rounded. The lobe on the umbilical wall is equally broad and shallow but is subangular. The internal suture consists of a moderately long sagittate dorsal lobe and on either side of it a narrower rounded club-shaped saddle, a shorter, obtusely-pointed, tongue-shaped lobe, and a broad, shallow, broadly rounded asymmetrical saddle which extends to the lobe on the umbilical wall.

Remarks. This species apparently is the most abundant form in the fauna under consideration, and it is represented in the collection being studied by thirty-five individuals. It belongs together with *Gastrioceras montgomeryense* (Miller and Gurley) and the form described below as *G. angusticameratum* n. sp., in the group of *G. subcavum* (Miller and Gurley), which is characterized by the possession of low flat whorls, wide, deep, funnel-shaped umbilici, and extremely angular umbilical shoulders. It is strikingly similar to *G. subcavum*, but its sutures are not precisely similar and the median saddle in the ventral lobe is much larger, the transverse constrictions on the internal mold are more numerous and more strongly sinuous, and the surface of the conch is much more highly ornate; the ornamentation of immature representatives of this species is more or less intermediate between that of *G. subcavum* and *G. montgomeryense*.

Occurrence. Upper Pennsylvanian (Abo?) sandstone, one and one-fourth miles east of Tularosa, New Mexico.

Cotypes. Peabody Museum of Natural History, Yale University, 13087.

GASTRIOCERAS ANGUSTICAMERATUM
A. K. Miller, n. sp.

Plate 13, figures 21-23

Gastrioceras sp. BÖSE, *1920*, Am. Jour. Sci., ser. 4, vol. 49, p. 58.

Form subglobose; conch rapidly expanded orad, strongly depressed dorso-ventrally, and slightly involute. Whorls are very broadly rounded ventrally, subangular ventro-laterally, slightly convex laterally, slightly concave dorsally, and subtrapezoidal in

cross-section. Height of whorl equal to almost half maximum width, which is attained at subangular umbilical shoulders, and depth of impressed zone appears to equal about one-third height of whorl. Umbilicus large, deep, and funnel-shaped, and diameter of umbilicus is equal to more than half that of specimen. Umbilical wall nearly straight but slightly convex and moderately steep. Holotype, which is septate throughout and therefore represents only part of phragmacone, was crushed and greatly distorted during preservation, but the preserved part of it appears to have had a maximum diameter of about 10 mm., and the outer whorl apparently attained a maximum height of about 4 mm. and a maximum width of about 9 mm.

Outer volution of holotype is marked by about seven rounded sinuous transverse constrictions, which are rather indistinct. They curve slightly apicad as they cross the umbilical wall and the ventro-lateral zones of the conch and somewhat more strongly orad as they cross the broad ventral zone; they are essentially parallel to the growth-lines which are rather coarse and very distinct on both the umbilical wall and the broadly rounded ventral part of the holotype, an internal mold. There is a suggestion of nodosity on the subangular umbilical shoulders, but if such existed on the conch, it was only very faintly impressed on the internal mold.

The septa of this species are very numerous and very closely spaced; six sutures occur in a length (measured along the venter) equal to the width of the conch, and the species is readily differentiated from similar forms by this characteristic alone. Each external suture consists of a moderately broad ventral lobe and on each side of it two saddles and one lobe; the second saddle is on the umbilical shoulder, and it is followed by a lobe on the umbilical wall. The ventral lobe is short and broad (its width and its length are approximately equal) and its sides are essentially straight and parallel; it is divided by a large median saddle which is distinctly more than half as deep as the lobe is long, is almost straight-sided and U-shaped, but is divided centrally by a small rounded tertiary saddle on either side of which there is a small, but very distinct, rounded tertiary lobe. The two lateral subdivisions of the ventral lobe are only about half as wide as the intermediate saddle, are sublanceolate in shape, slightly asymmetrical, and narrowly rounded. The external saddle is almost as long as the ventral lobe but is narrower, almost straight-sided, rounded, and therefore U-shaped. The lateral lobe is slightly narrower than the external saddle, is somewhat tongue-shaped, and is obtusely pointed. The saddle on the umbilical shoulder is broad, shallow, broadly rounded, and asymmetrical. The lobe on the umbilical wall is still broader and shallower and is subangular. The internal suture is not visible on the holotype and only known representative of this species, but it undoubtedly is similar to that of *G. subtilicostatum* Böse, described above.

Remarks. The above description is

based on a single specimen which is an internal mold indifferently preserved in limonite and greatly crushed and distorted. This species is obviously closely related to *G. subtilicostatum,* but differs from it in that the septa are much more closely spaced and therefore the camerae are much shorter, the transverse constrictions are much less prominent on the internal mold at least, the surface of the test apparently is less ornate, and the sutures are not precisely similar in that the median saddle in the ventral lobe is divided centrally by a small tertiary saddle rather than a tertiary lobe. The short camerae and numerous transverse constrictions as well as obvious differences in the sutures distinguish this form from *G. subcavum* (Miller and Gurley), and the lack of prominent umbilical nodes as well as differences in the spacing and shape of the sutures distinguish it from *G. montgomeryense* (Miller and Gurley).

Occurrence. Upper Pennsylvanian (Abo?) sandstone, one and one-fourth miles east of Tularosa, New Mexico.

Holotype. Peabody Museum of Natural History, Yale University, 13088.

GASTRIOCERAS BAKERI A. K. Miller, n. sp.

Plate 13, figures 15-17

Gastrioceras sp. BÖSE, *1920,* Am. Jour. Sci., ser. 4, vol. 49, p. 57.

Form subglobose and conch is moderately expanded orad, depressed dorso-ventrally, and deeply involute. Whorls are broadly rounded ventrally and laterally, are deeply impressed dorsally, and are therefore almost semicircular in cross section. Height of whorl equal to about two-thirds maximum width, which is attained just ventrad of umbilical shoulders, and depth of impressed zone equals almost one-half height of whorl. Umbilicus moderately small but deep; width of umbilicus equal to about two-fifths diameter of specimen, and umbilicus is distinctly more than half as deep as wide. Umbilical shoulders rounded and more or less indistinct. Umbilical wall rather strongly convex but steep. Maximum diameter of holotype, a nearly complete, typical, mature individual, measures about 9.50 mm.; maximum width of whorl, about 6.25 mm.; maximum height of whorl, about 4 mm.; maximum depth of impressed zone, about 1.75 mm.; maximum diameter and depth of umbilicus, about 4 mm. and 2.50 mm., respectively.

Each volution of conch is marked by three or four rounded constrictions which are almost transverse to the long axis of the conch but curve slightly orad as they cross the broad ventral zone of the specimen. In adolescent individuals these constrictions are very prominent and there are four of them to the volution, but in large, mature individuals, like the holotype, they are much less prominent, though quite distinct, and there are only three of them to the volution. They are approximately parallel to the growth-lines.

Both the test and the internal mold are marked also by numerous fine transverse growth-lines, which curve slightly orad as they cross the broad ventral zone of the conch and are therefore approximately parallel to the

transverse constrictions. Böse states that they begin on the umbilical wall and bifurcate on the flanks of the whorls; it is true that they become much less distinct on the dorsal part of the umbilical wall, but they are continuous across that wall and the dorsal side of the whorls; also, whereas on the internal mold, locally, at lease, they appear to bifurcate slightly ventrad of the umbilical border, on fragments of the test that adhere to the holotype and several of the paratypes, it can be seen quite clearly that they do not bifurcate but that each is distinct and continuous. They are much more prominent on the umbilical walls of the earlier volutions than on those of the outer ones. The rounded umbilical shoulders are marked also by two very distinct and three or four faint longitudinal lirae; these are conspicuous on the test of mature individuals but they are not impressed on the internal mold and are only barely discernible on the test of smaller individuals.

The external suture consists of a moderately broad ventral lobe and on each side of it two saddles and one lobe; there is an additional lobe on the umbilical wall. The ventral lobe is short and broad (approximately as wide as long) and its sides are almost straight and are nearly parallel. It is divided by a short, broad median saddle which is about two-fifths as deep as the lobe is long and is almost straight-sided and U-shaped but is divided centrally by a small subangular tertiary lobe. The lateral subdivisions of the ventral lobe are only about half as wide as the intermediate saddle and are sublanceolate in shape. The external saddle is almost as long as the ventral lobe but is distinctly narrower and is asymmetrically U-shaped. The lateral lobe is slightly narrower than the external saddle, is obtusely pointed, and is more or less tongue-shaped. The lateral saddle is wide, moderately deep, broadly rounded, and distinctly asymmetrical. The lobe on the umbilical wall is short, broad, and subangular. The internal suture consists of a moderately long, narrow, obtusely pointed, tongue-shaped dorsal lobe, the adapical part of which is in contact or nearly so with the preceding suture, and on either side of it a shorter, slightly wider, U-shaped saddle, a much shorter, narrower, pointed, tongue-shaped lobe, and a broad, moderately shallow, asymmetrical saddle that extends to the lobe on the umbilical wall.

Remarks. This species is one of the most abundant forms in the fauna under consideration, and whereas the above description is based largely on the holotype and a single paratype which shows the internal sutures, thirty other specimens are available for comparison. The spacing of the septa varies somewhat, and in some of the specimens that are being referred to this species there is a suggestion of nodes on the umbilical shoulders, but all show the same general characters as the holotype.

Böse compared this form to *Gastrioceras illinoisense* (Miller and Gurley), *G. roadense* Böse, and *G. modestum* Böse, but the similarity is not

great and the relationship is not close. This species is however closely related to both *G. drakei* n. sp., and *G. multiseptum* n. sp., with which it occurs in association. Its rounded, more or less indistinct umbilical shoulders, which are distinctly reticulate, serve to differentiate it from both of those forms, and in addition its septa are much less numerous than are those of *G. multiseptum*, and its umbilical shoulders are not nodose as are those of *G. drakei*.

The species is named in honor of Mr. Charles L. Baker, who, together with Dr. N. F. Drake, collected the fossils on which this report is based.

Occurrence. Upper Pennsylvanian (Abo?) sandstone, one and one-fourth miles east of Tularosa, New Mexico.

Types. Peabody Museum of Natural History, Yale University, 13089 (holotype), 13090 (paratypes).

GASTRIOCERAS DRAKEI A. K. Miller, n. sp.

Plate 13, figures 12-14

Gastrioceras sp. BÖSE, *1920*, Am. Jour. Sci., ser. 4, vol. 49, pp. 56-57.

Form subglobose and conch is moderately expanded orad, depressed dorso-ventrally, and deeply involute. Whorls are broadly rounded ventrally and ventro-laterally, subangular laterally, and impressed dorsally. Height of whorl equal to about two-thirds maximum width, which is attained at umbilical shoulders, and depth of impressed zone equal to about one-half height of whorl. Umbilicus moderately large and deep; width of umbilicus equal to almost half diameter of specimen, and umbilicus is almost twice as wide as deep. Umbilical shoulders subangular. Umbilical wall rather strongly convex and inclined to dorso-ventral plane of conch at some forty-five degrees. Maximum diameter of holotype, a nearly complete, typical, mature individual, measures about 8.5 mm.; maximum width of whorl, about 5.5 mm.; maximum height of whorl, about 3.5 mm.; maximum depth of impressed zone, about 1.5 mm.; and maximum width and depth of umbilicus, about 4 mm. and 2.5 mm., respectively.

Each volution of conch is marked by three very distinct, rounded transverse constrictions which are slightly sinuous. They curve very slightly apicad as they cross the lateral zones of the conch and distinctly orad as they cross the broad ventral zone. They are almost parallel to the growth-lines but are distinctly more sinuous.

On the umbilical wall of the outer volution of the holotype there are about forty small transverse ribs or costae. These die out dorsally and do not reach the umbilical seam; the dorsal side of the conch is marked only by numerous fine transverse growth-lines, which however are very distinct. The costae of the umbilical walls swell into very small, more or less indistinct nodes on the umbilical shoulders, and from each of these nodes two fine costae or raised lines continue across the broadly rounded ventral portion of the conch; these curve orad rather strongly and are almost parallel to the transverse constrictions but are distinctly less sinuous. This ornamentation is very distinct on the internal

mold as well as on the exterior of the test. There is no trace of longitudinal lirae either on the internal mold or the test.

The external suture consists of a moderately broad ventral lobe and on each side of it two saddles and one lobe; there is an additional lobe on the umbilical wall. The ventral lobe is short and broad (approximately as wide as long) and its sides are almost straight and are essentially parallel; it is divided by a short, broad median saddle which is about one-fourth as deep as the lobe is long and is straight-sided and U-shaped but is divided centrally by a small angular tertiary lobe. The two lateral subdivisions of the ventral lobe are narrower than the intermediate saddle, almost straight-sided, symmetrical, and inverted-U-shaped. The external saddle is shorter and narrower than the ventral lobe and is asymmetrically U-shaped. The lateral lobe is short, broad, symmetrical, and more or less tongue-shaped; it is so narrowly rounded as to appear almost subangular. The lateral saddle is broad, moderately deep, broadly rounded, and very asymmetrical. The lobe on the umbilical wall is short, broad, and very narrowly rounded. The internal suture is not visible on any of the types, but it doubtlessly is comparable to that of *G. bakeri* n. sp., described above.

Remarks. The above description is based almost entirely on the holotype, but four less well preserved specimens are available for comparisons; all show the same general characters as the holotype and little variation other than in size is noticeable. Böse believed that these specimens represented two species or at least two varieties, and he states that one of them is more evolute than the other; the writer has not been able to substantiate this belief. Böse compared these specimens to *G. welleri* Smith, but the relationship is not close. They are however closely related to both *G. bakeri* n. sp., and *G. multiseptum* n. sp., with which they are associated, but their sutures are not precisely similar and the umbilical shoulders are not nodose in either of those forms. Also, in *G. multiseptum* the septa are much more numerous and more closely spaced, and in *G. bakeri* the umbilicus is smaller, the umbilical shoulders are less distinct, are rounded rather than angular, and are marked by longitudinal lirae rather than nodes.

This species is named in honor of Dr. N. F. Drake, who, with Mr. C. L. Baker, collected the fossils on which this report is based.

Occurrence. Upper Pennsylvanian (Abo?) sandstone, one and one-fourth miles east of Tularosa, New Mexico.

Types. Peabody Museum of Natural History, Yale University, 13091 (holotype), 13092 (paratypes).

GASTRIOCERAS MULTISEPTUM A. K. Miller, n. sp.

Plate 13, figures 9-11

Gastrioceras sp. Böse, *1920*, Am. Jour. Sci., ser. 4, vol. 49, p. 58.

Form subdiscoidal and conch is rapidly expanded orad, depressed dorso-ventrally, and deeply involute, and whorls are broadly rounded ventrally and laterally, impressed dorsally,

and almost semi-circular in cross-section. Height of whorl equal to about two-thirds maximum width, which is attained at umbilical shoulders, and depth of impressed zone equal to slightly more than one-third height of whorl. Umbilicus moderately large and deep; width of umbilicus equal to almost half diameter of specimen. Umbilical shoulders narrowly rounded but very distinct; umbilical wall almost straight and moderately steep. Maximum diameter of holotype which is septate throughout and therefore represents only part of the phragmacone, measures about 7 mm.; maximum width of whorl, about 4.5 mm.; maximum height of whorl, about 3 mm.; maximum depth of impressed zone, about 1.25 mm.; maximum diameter of umbilicus, about 3 mm. Outer volution of holotype is marked by three fairly distinct rounded constrictions which are approximately transverse to long axis of conch but curve slightly orad as they cross the broadly rounded ventral part of the specimen. Faint impressions of growth-lines are also discernible on both the holotype and the single paratype, and these are parallel (or very nearly so) to the transverse constrictions, but on the dorsal side of the conch they are directly transverse. There is no indication of either nodes or longitudinal lirae on the umbilical shoulders of the holotype, but there is a suggestion of small nodes on those of the paratype.

The septa of this species are very numerous and very closely spaced: seven sutures occur in a length (measured along the venter) equal to the width of the conch, and the adapical third of the ventral side of the external saddle is almost in contact with the adoral third of the ventral side of the external saddle of the adjacent suture; the dorsal side of that saddle is relatively far from the adjacent suture. The internal sutures of the conch are still more crowded, and the adapical half of the ventral lobe and in some cases as much as a third of the lateral lobe are in contact (or nearly so) with the preceding suture. This crowding of the septa is the most distinctive character of the species and it gives it its name and serves to differentiate it from other similar forms with the exception of *G. angusticameratum* n. sp., in which the conch is much more strongly depressed dorso-ventrally, the whorls are exceedingly angular laterally, the umbilicus is much larger, and the lobes of the sutures are sharper.

Each external suture consists of a moderately broad ventral lobe and on each side of it two saddles and one lobe; there is an additional lobe on the umbilical wall. The ventral lobe is short and broad (slightly wider than long), and its sides are almost straight and nearly parallel; it is divided by a short, broad median saddle which is about two-fifths as deep as the lobe is long and is straight-sided and U-shaped but is divided centrally by a small subangular tertiary lobe. The two lateral subdivisions of the ventral lobe are narrower than the intermediate saddle, almost straight-sided, nearly symmetrical, and narrowly rounded. The external saddle is shorter and narrower than the ventral lobe and is

almost U-shaped, but it is asymmetrical, its sides are not quite straight, and it is rather narrowly rounded. The lateral lobe is shorter and broader and is subangular to obtusely pointed. The lateral saddle is broad, moderately deep, broadly rounded and asymmetrical. The lobe on the umbilical wall is short, broad, subangular, and symmetrical or nearly so.

The internal suture consists of a moderately long, narrow, subangular to narrowly rounded, lanceolate dorsal lobe and on each side of it a much shorter, broader, rounded, U-shaped saddle, a shorter, broader, bluntly pointed, tongue-shaped lobe, and a broad, moderately deep, broadly rounded, asymmetrical saddle that extends to the lobe on the umbilical wall.

Remarks. The above description is based on the holotype and a single fragmentary paratype; both are internal molds indifferently preserved in limonite, and both are septate throughout and therefore represent only part of the phragmacone. The holotype was slightly crushed and distorted during preservation. The paratype reveals the nature of the internal sutures.

This species is similar to *G. bakeri* n. sp., and *G. drakei* n. sp., which occur in association with it, but the numerous septa and the lack of distinct ornamentation on the umbilical borders serve to distinguish it from both of those forms.

Occurrence. Upper Pennsylvanian (Abo?) sandstone, one and one-fourth miles east of Tularosa, New Mexico.

Types. Peabody Museum of Natural History, Yale University, 13093 (holotype), 13094 (paratype).

GASTRIOCERAS PAUCIRETICULATUM
A. K. Miller, n. sp.
Plate 13, figures 1, 2
Gastrioceras sp. BÖSE, *1920,* Am. Jour Sci., ser. 4, vol. 49, p. 58.

Form subglobose; conch expanded orad moderately rapidly and strongly depressed dorso-ventrally; whorls impressed to about one-half their height by preceding volution and crescent-shaped in cross-section. Height of whorl equal to only slightly more than half maximum width, which is attained just ventrad of umbilical shoulders. Umbilicus deep and moderately large and umbilical walls of all of earlier volutions of conch visible; width of umbilicus equal to slightly more than one-third diameter of specimen. Umbilical shoulders rounded; umbilical wall steep and inclined to lateral sides of conch at some 60-70 degrees. Unfortunately all of the type specimens were crushed and distorted during preservation, and therefore detailed measurements do not have their usual significance. Nevertheless the following are doubtless worth recording: maximum diameter of holotype, about 8 mm.; maximum width, about 5 mm.; maximum width and depth of umbilicus, about 3 mm., and 2 mm., respectively; near adapical end of outer whorl of holotype, conch appears to be only very slightly distorted and height of whorl measures about 2.5 mm. and maximum width about 4 mm.

Surface of conch marked by numerous fine transverse lirae which curve slightly orad as they cross the broad ventral zone of the conch; these appear to be somewhat more prominent on the umbilical wall and on the umbilical shoulders than on the lateral

and ventral zones of the conch, but this may be due to differences in amount of abrasion or to differences in preservation. On the rounded umbilical shoulders these transverse lirae are crossed by four equally prominent longitudinal lirae and possibly one or two additional very faint ones; the umbilical borders are therefore reticulate, but only transverse lirae are present on the rest of the conch. Sutures not visible on any of the types, but the outer whorl of the smallest of the paratypes appears to be marked by three or four sinuous constrictions which are approximately transverse to the long axis of the conch but curve slightly orad as they cross the venter.

Remarks. The above description is based almost entirely on a single specimen which is fairly well preserved in limonite, but unfortunately was crushed and distorted during preservation. Two paratypes are available for comparisons, but they are not well enough preserved to add appreciably to our knowledge of the species; one of them is slightly larger than the holotype and the other is slightly smaller. Unfortunately the sutures are not visible on any of the types and the nature of the preservation of the specimens makes it impossible to prepare them so that the shape of the sutures can be determined. Nevertheless, the general shape of the conch and the associations make it clear that the affinities of this form are with *Gastrioceras* and it is accordingly referred to that genus.

The surface ornamentation of the conch, particularly the reticulate umbilical borders, serve to distinguish this species from all other described representatives of the genus, and the writer knows of no species to which it can be compared profitably, unless it is *G. bakeri* n. sp., the umbilical borders of that form also are reticulate, but the longitudinal lirae are much less strongly developed even in large mature specimens, and in specimens the size of the holotype of the species under consideration they are only barely discernible. This ornamentation does not appear to be at all comparable to that of the reticulate forms recently referred by Bisat[18] to *Homoceras* Hyatt and *Reticuloceras* Bisat.

Occurrence. Upper Pennsylvanian (Abo?) sandstone, one and one-fourth miles east of Tularosa, New Mexico.

Types. Peabody Museum of Natural History, Yale University, 13095 (holotype), 13096 (paratypes).

[18] Bisat, W. S., The Carboniferous goniatites of the North of England and their zones: *Yorkshire Geol. Soc. Proc.*, vol. 20, pt. 1, pp. 102-119, 1924.

* *Note from p. 62.* Since this paper was written some corroborative evidence for this correlation has come to hand. The writer has recently had the privilege of examining the private collection of John Britts Owen, Clinton, Missouri, which contains numerous ammonoids that apparently came from the same horizon and locality as those described in this report; amongst them is a specimen that represents an undescribed species of the genus *Shumardites*. Only two species of that genus have so far been described: *S. simondsi* Smith, of the Wayland shale, near Graham, Texas, and *S. keideli* Leuchs, of the central Tien Shan, near the eastern border of Russian Turkeston. The conch of the former is smooth and that of the latter is marked by longitudinal lirae, whereas that of the Tularosa specimen is marked by very distinct transverse lirae. The occurrence of this genus in the central Tien Shan confirms the writer's conclusion (Am. Jour. Sci., 5th ser, vol. 22, 1931, p. 417) that strata containing a fauna related to that of the Cisco of Texas are present in Central Asia.

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AMERICAN SPECIES OF THE GENUS *DICTYOCONUS*

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ABSTRACT

This paper presents a brief revision of the species of *Dictyoconus* Blanckenhorn at present known in the Tertiary formations of America. The genus name *Cushmania* Silvestri proposed for *Conulites americanus* is definitely placed in the synonymy of *Dictyoconus. Dictyoconus puilboreauensis* Woodring is combined with *D. codon* Woodring, the former being the megalospheric, the latter the microspheric form of the same species. *D. puilboreauensis nannoides* Woodring is retained as a subspecies of *D. codon* Woodring. *Cushmania fontabellensis* Vaughan is referred to *Dictyoconus,* and the specimens identified by Vaughan as *Cushmania americana* from Fontabella, Jamaica, are considered the megalospheric form of *D. fontabellensis* (Vaughan). The doubt in the generic identification of *Dictyoconus? gunteri* M. W. Moberg is removed and the species is definitely referred to *Dictyoconus.*

The following species of *Dictyoconus, D. americanus* (Cushman), *D. codon* Woodring (and its subspecies *nannoides* Woodring), *D. fontabellensis* (Vaughan), and *D. gunteri* M. W. Moberg are recognized. The stratigraphic range of the genus in America is from middle to upper Eocene.

INTRODUCTION

Several of my scientific correspondents have appealed to me to clear away doubt regarding some of the structural features of Cushman's *Conulites americanus,* which Silvestri made the type species of a genus to which he applied the name *Cushmania.* Since the only type material of the species is that which I collected in 1914 in St. Bartholomew, W.I., and donated to the United States National Museum, I am at present the only one who is in a position to make the needed additional study.

Since my account of the Jamaican species of *Dictyoconus* and *Cushmania* (Vaughan, 1928) was not satisfactory to me at the time that I published it I have wished to revise it, and as I have at my disposal representative material of the other American species, I have made a restudy of them as well.

I have available for comparison specimens of *Dictyoconus aegyptiensis* (Chapman) from Egypt, kindly sent to me by Prof. G. Stefanini of Modena and Col. L. M. Davies, at present at Leith Fort, Edinburgh. Colonel Davies has also sent specimens of the Indian species of *Dictyoconus, Coskinolina, Lituonella,* and *"Conulites" (Dictyoconoides)*, described by him, and specimens of *Lituonella roberti* from France. I have no European specimens of *Coskinolina* nor any specimens of *Chapmania.*

As the papers that I have published on the larger foraminifera collected by

Doctor Matley in Jamaica do not contain an account of the species of *Coskinolina* collected by him, I had intended writing another paper which would be especially devoted to them, but that now appears unnecessary since the additional study of the Jamaican material will probably be made by Colonel Davies who will utilize the specimens that have been sent to the British Museum (Natural History). Mr. G. M. Ponton of the Florida State Geological Survey is studying the material representing *Dictyoconus, Coskinolina,* and related forms found in the deep wells of Florida. The present note should be considered in its relations to the studies contemplated or actually in progress by Colonel Davies and Mr. Ponton.

Colonel Davies has recently published an excellent account of the structural differences between typical specimens of *Dictyoconus, Coskinolina,* and *Lituonella* (Davies, 1930). The marginal trough in *Lituonella* is an undivided furrow which follows the lower peripheral edge of the test; the marginal trough in *Coskinolina* is divided into a succession of rectangular chamberlets; the chamberlets of the marginal trough in *Dictyoconus* are subdivided by other partitions. I am calling these smallest spaces "cellules" in the following descriptions.

Citations to the literature in the following discussion of species refer to the bibliography at the end of this paper.

DISCUSSION OF SPECIES

DICTYOCONUS AMERICANUS (Cushman) Vaughan

Plate 14, figures 3-5

Conulites americana CUSHMAN, *1919,* p. 43, fig. 3.
Cushmania americana, SILVESTRI, *1925,* p. 52.
Cushmania americana (part) VAUGHAN, *1928,* pp. 281, 282.

Cushman's original description of *Conulites americana* is as follows:

> Test conical, height about two-thirds the width at the base, apex broadly rounded, base slightly convex, peripheral angle subacute, the peripheral region standing out somewhat from the general conical mass of the rest of the test; early chambers spirally arranged, later ones annular, exterior of test in section tubular, central portion made up of irregularly curved chambers, more or less irregularly divided into labyrinthic subdivisions; surface fairly smooth.
>
> Diameter at base slightly less than 2 mm.
>
> Type specimen (U.S.N.M. No. 328179), section from station 6902, southeast section of southwest side of island near Nègre Point, elevation 360 feet, St. Bartholomew, Leeward Islands. . . .
>
> This is similar to the *C. aegyptiensis* Chapman from the Eocene of Egypt and Italy, but differs in its general proportions and in the flange-like extension of the peripheral border at the base.

Silvestri (1925) published the following:

> *Orbitolina* e *Dictyoconus, Conulites americana* e *Coskinolina, Conulites Cooki* e *Chapmania* ci rappresentano press'a poco il medesimo livello evolutivo, le forme finali convergenti, di gruppi morfologici diversi, quindi trovo necessario cambiare il nome del genere alla arenacea *Conulites americana,* che ha una muraglia sua particolare a sepimenti (o forse pali) fitti ed uniformi, ed un riempimento interno rassomigliante a quello della *Coskinolina liburnica,* per cui non è nè l'uno, nè l'altra ed d'altra parte nemmeno una *Conulites,* perchè in questa la

muraglia è a cassettoni, come nelle *Chapmaniae,* proponendo per essa *Conulites americana,* la istituzione del nuovo genera *Cushmania,* del quale essa medesima viene a darci il tipo illustrato dallo scienziato americano, al quale dedico, com è doveroso, il nuove genere.

Regarding the relationship of *Cushmania* to *Dictyoconus* I have said, in discussing specimens from Jamaica:

A variation of significance is that of the number and the degree of thickening of the minute, short lamellae that project from the lateral walls into the cavities between the successive skeletal floors. On the right-hand side of plate 43, figure 1, the number in each space is small, only one, two, or three; but on the left-hand side of the same figure they are more numerous, four being common, and, therefore, more crowded. In the specimen represented by plate 43, figure 2, they are as on the left side of figure 1. In figure 3, of the same plate, the number is somewhat larger, consequently with more crowding, and there is considerable anastomosis, especially near the summit of the specimen. The condition in this last-mentioned specimen is very near that represented in *Cushmania* (Silvestri, 12, p. 52), which will be more fully discussed under species referred to that genus. (Vaughan, 1928, p. 281). . . . it appears to me that the mural features of *Dictyoconus* and *Cushmania* intergrade, as has been indicated in discussing *Dictyoconus codon.* . . . (Vaughan, 1928, p. 282).

Since Cushman's original description of the general features of this species is adequate it is necessary here only to add supplemental detail. Plate 14, figure 4, shows that the test may be more conical than the type specimen and the periphery of the base may not exhibit the slight upward curve of the type.

The marginal trough is shown by both vertical (pl. 14, figs. 3, 4) and horizontal (pl. 14, fig. 5) sections to be divided into chamberlets which are subdivided by plates into cellules, as in *Dictyoconus.* The specimen, of which Plate 14, figure 5, illustrates a horizontal section, is in the plane of the section about 0.51 mm. in diameter. By comparing this figure with Plate 14,

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EXPLANATION OF PLATE 14

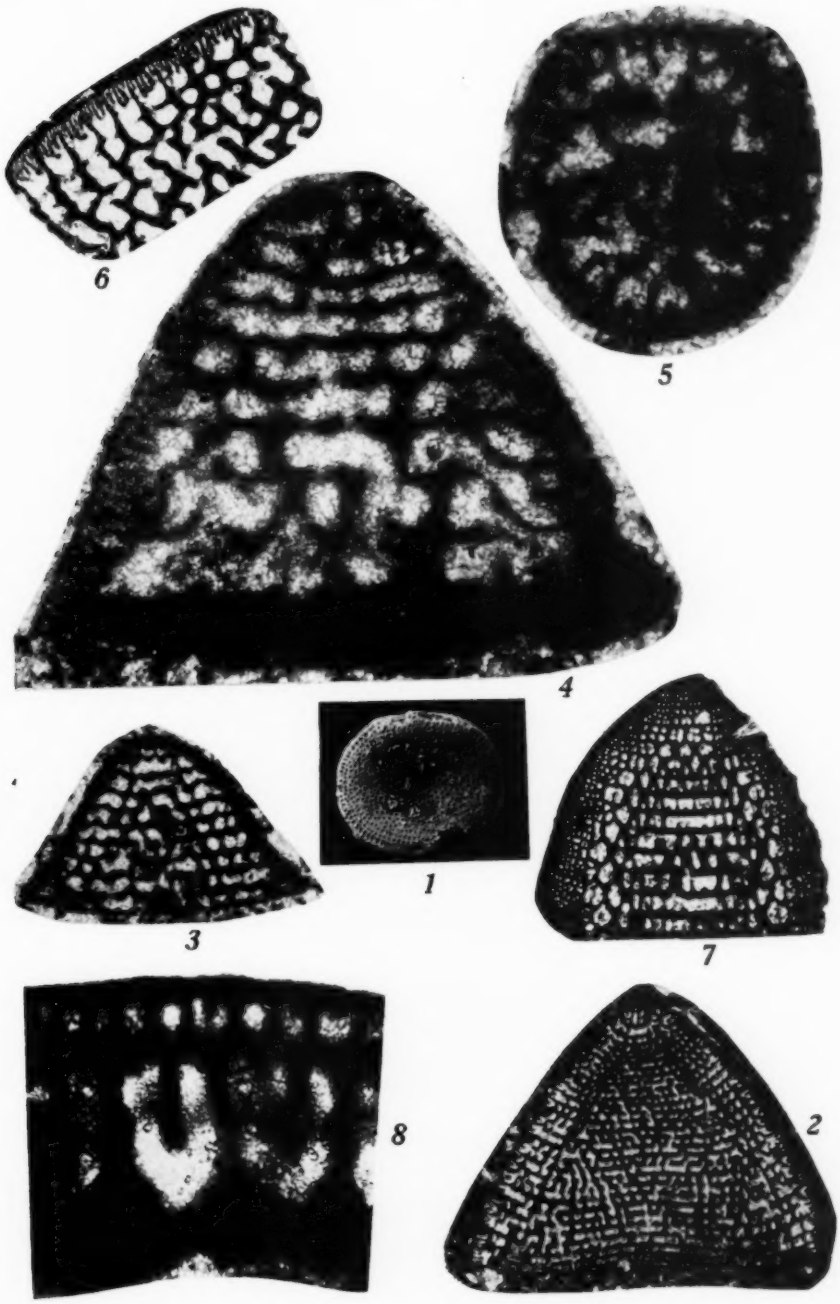
FIGS. 1, 2—*Dictyoconus codon* Woodring. 1, View of base, × 5, to show marginal trough. Republication of illustration, Vaughan, 1928, pl. 43, fig. 4b. 2, Vertical section, × 10, to show partitions in the marginal trough, Republication of illustration, Vaughan, 1928, pl. 43, fig. 2.

3-5—*Dictyoconus americanus* (Cushman) Vaughan. 3, Vertical section, × 20, of *type specimen.* 4, Vertical section, × 80, of specimen in type material. 5, Horizontal section, × 80, of specimen in type material.

6, 7—*Dictyoconus fontabellensis* (Vaughan) Vaughan. 6, Vertical section of outer wall of type specimen, × 20, to show partitions in the marginal trough. Republication of part of an illustration, Vaughan, 1928, pl. 44, figs. 3, 7. Section along a secant plane, × 20, to show cellules in the marginal trough. Specimen in the same rock as the type specimen. Republication of illustration, Vaughan, 1928, pl. 44, fig. 2.

8—*Dictyoconus gunteri* M. W. Moberg, nearly horizontal section, × 100, of specimen from well, depth 2,000 ft., Marathon, Florida. This species was identified by Vaughan, 1923, as *D. codon* Woodring.

(All the specimens illustrated, except fig. 8, are the property of the United States National Museum.)



Vaughan—Dictyoconus

figure 4, it can be seen that the section is about 0.4 mm. below the apex. The usual number of subdivisions of each chamberlet is three. The vertical sections, Plate 14, figures 3, 4, show subdivision of the chamberlets as in *Dictyoconus* except that the spaces between the plates are more completely filled by deposit than is usual in *Dictyoconus*. The fundamental structure in both *"Cushmania"* and *Dictyoconus*, however, is the same. The figures here given should be compared with those of *Dictyoconus* published by Colonel Davies in his paper already cited.

Locality and geologic horizon. The type locality is given in the quotation from Cushman. The specimens here used in extending the description are not only from the same locality but from the same rock as the type specimen. The geologic horizon has been given as upper Eocene, but I am not sure of the correctness of this opinion. Associated with *D. americanus* is *Lepidocyclina (Polylepidina) antillea* Cushman. Cole has recently described a species, *Lepidocyclina (Polylepidina) gardnerae*, from the middle Eocene of east Texas (Cole, 1929). This species so closely resembles *L. antillea* Cushman that I am not convinced that it is distinct from that species. The horizon of *Dictyoconus americanus* and *Lepidocyclina antillea* may be middle instead of upper Eocene.

Besides the type locality, Cushman lists three localities in Cuba under his *Conulites americana*. I have reexamined the sections. They seem to represent *Dictyoconus* but positive identification is doubtful.

DICTYOCONUS CODON Woodring

Plate 14, figures 1, 2

Dictyoconus codon WOODRING, *1924*, p. 608.—VAUGHAN, *1923*, p. 254; *1928*, p. 280, pl. 43, figs. 1-5b.

Dictyoconus puilboreauensis WOODRING, *1924*, p. 609.—VAUGHAN, *1928*, p. 281, pl. 43, fig. 6.—DAVIES, *1930*, p. 504, pl. 56, fig. 12.

Woodring, at the time that he proposed the names given above, suggested that the two forms were probably only the microspheric and megalospheric generations of the same species. I am convinced that that suggestion is correct. *D. codon* is the microspheric and *D. puilboreauensis* is the megalospheric form.

Localities and geologic horizon. Type locality, north side of Mt. Puilboreau, Republic of Haiti, in the middle Eocene Plaisance limestone. In Jamaica at several localities in the middle Eocene "Yellow limestone." The first collection of *D. codon* at the type locality was made by me in 1919.

DICTYOCONUS CODON NANNOIDES Woodring

Dictyoconus puilboreauensis nannoides WOODRING, *1924*, p. 689, pl. 13, figs. B, C.

This variety of *D. codon* is very similar to *D. americanus*. The chief difference consists in the presence of more deposit between the partitions that divide the chamberlets into cellules in *D. americanus*.

Localities and geologic horizon. Numerous places in the upper Eocene of the Republic of Haiti.

DICTYOCONUS FONTABELLENSIS (Vaughan) Vaughan

Plate 14, figures 6, 7

Cushmania fontabellensis VAUGHAN, *1928*, p. 282, pl. 44, fig. 3.

Cushmania americana VAUGHAN, part, *1928*, p. 281, pl. 44, figs. 1, 2.

A restudy of the specimens from locality J. 22 M., Fontabella, at River Rise, Trelawny, Jamaica, collected by Dr. C. A. Matley and identified by me as *Cushmania americana,* has convinced me that they do not belong to that species, but that they are the megalospheric form of *D. fontabellensis,* the type specimen of which is a microspheric specimen.

Locality and geologic horizon. River Rise, Fontabella, Trelawny, Jamaica; upper Eocene.

DICTYOCONUS GUNTERI M. W. Moberg
Plate 14, figure 8

Dictyoconus? gunteri M. W. MOBERG, *1928,* p. 168, pl. 3, figs. 9-10, pl. 4, figs. 1-3.

I have recently studied additional material representing this species. The marginal trough is divided into chamberlets, which are further subdivided into cellules in the manner characteristic of *Dictyoconus.* Therefore the question mark placed by Mrs. Moberg after her generic identification may be removed. I first identified this species as *D. codon* Woodring (Vaughan, 1923).

Localities and geologic horizon. The type locality, well near York, Marion Co., Florida, depth 950-980 ft.; and in deep wells at Marathon, Florida. The horizon is supposed to be middle Eocene.

DIFFERENCES BETWEEN THE AMERICAN SPECIES OF *Dictyoconus*

Although all the known specimens of *D. americanus* are small, these specimens may be young and size may not be of specific significance. Apparently the different species may be separated on a basis of the height of the interspaces between the platforms and the details of the marginal trough.

Platforms most crowded, distance between them near the center, about 0.04 mm. or even less; at the periphery, 0.06 to 0.08 mm. Only a few cellules.....*D. gunteri*

Platforms near the center about 0.05 mm. apart; at the periphery, as much as 0.10 mm. Cellules more numerous than in *D. gunteri* .....*D. codon*

Platforms near the center, 0.038 to 0.054 mm. apart. Cellules relatively numerous but the cavities may be filled with compacting substance. All known specimens small .....*D. americanus*

Platforms in microspheric specimen near the center, from 0.05 mm. apart at the base to as much as 0.175 mm. apart near the summit; at the periphery from 0.175 to 0.20 mm. apart. This is the coarsest-textured species. Cellules the most numerous in any species of the series .....*D. fontabellensis*

GEOLOGIC HORIZONS OF AMERICAN SPECIES OF *Dictyoconus*

Middle Eocene	*Dictyoconus codon* Woodring
Probably Middle Eocene	*Dictyoconus gunteri* Moberg
	Dictyoconus americanus Cushman
Upper Eocene	*Dictyoconus codon nannoides* Woodring
	Dictyoconus fontabellensis (Vaughan)

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PALEONTOLOGICAL NOTES

ORIGIN OF SPHERES IN THE GEORGETOWN LIMESTONE[1]

H. DIGHTON THOMAS
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Thin-sections of the Georgetown limestone, collected from the upper part of the formation along the Mt. Bonnel road west of Austin, Texas, have been shown to the staff of the geological department of the British Museum (Natural History), and their opinion is that there is nothing definitely organic recognizable about the "spheres." My opinion is that they are certainly not *Orbulina* but are inorganic, and most probably oölitic in origin, or due to some such process. Mr. Bairstow of this department has called attention to W. A. Tarr's paper, "Is the Chalk a Chemical Deposit."[2] wherein "spheres" are mentioned (pp. 254 and 255, especially). I have since examined a number of thin-sections of the English Chalk from the Hill Collection and am convinced that the small spheres so common in it, especially those in the middle chalk, are the same as those in the Georgetown limestone. Their average size is the same (average diameter about 0.06 mm.), and they show the same characters of a thin wall surrounding a space containing some calcite crystals that have obviously grown inward from the wall, just as in those of the Georgetown limestone. In one or two instances the bodies appear double, but this has been the result of one being crushed against other, and the walls of one or both are broken or distorted. Just as in the Georgetown limestone, so in the Chalk, the sections of some of these bodies are slightly elongated.

The problem of the origin of the bodies in the Georgetown limestone is then the same as that of the origin of those in the English Chalk. Jukes-Brown and Hill[2a] have discussed this, but they came to no definite conclusion. Hill says that their real nature "still remains an enigma."[3]

Thanks to Mr. Campbell Smith of our mineralogical department, I have been able to examine some preparations [G. J. Hinde Collection, now in the British Museum (Natural History)] of the isolated material of the Chalk. They have furnished a number of small spherical bodies, which I am sure are the same as those seen in thin-sections. These spheres have given no indication of an aperture, so that it is inconceivable that they are foraminifera, as has been suggested for those in the Georgetown limestone. It is interesting to note that as long ago as 1878 J. F. Blake[4] in recording these spheres in the Yorkshire chalk noted the absence of apertures and said that "otherwise they look like *Orbulina universa*," He obviously was sceptical of their foraminiferal origin.

The sections of the spheres in the Georgetown limestone and in the English Chalk show that from the wall crystalline calcite has grown inwards, and that the wall was formed around some non-solid nucleus generally. It recalls T. W. Vaughan's suggestion that oölitic grains may form around gas bubbles as nuclei.[5] Such an origin would give both a wall, which might conceivably show concentric structure, and also the space within it wherein crystallized calcite extending a greater or less distance toward the center could be formed. It is in some such way that these spherical bodies have probably originated.

The apparent concentric structure of some of the walls under high power is probably only an optical effect (Becker

[1] Published by permission of the Trustees of the British Museum.

[2] *Geol. Mag.*, vol. 62, pp. 252-264, 1925.

[2a] "Cretaceous Rocks of Britain," *Mem. Geol. Survey Great Britain*, vol. 2, 1903, chaps. 22, 23, 43; vol. 3, 1904, chap. 22.

[3] *Idem.*, vol. 2, p. 501.

[4] *Proc. Geol. Assoc.*, vol. 5, p. 266.

[5] *Jour. Washington Acad. Sci.*, vol. 3, p. 303, 1913.

"white line" perhaps), and the black "cross" seen in the wall under crossed nicols is of little help.

The examination of limestones of other ages has led to interesting results. For obvious reasons, the best for the purpose are those that have not undergone too much recrystallization. Three sections of Carboniferous limestone (one from Castletown, Isle of Man; one from Clifton near Bristol; and one from Dulcot, near Wells, Somerset) show bodies somewhat similar to those in the Cretaceous limestones both in size and character. From the meager material examined, I hesitate to say definitely that they are the same as those of Cretaceous age, but the similarity is very great indeed, especially those in the rock from the Isle of Man, and the point is therefore not without interest. In a section of the Coniston limestone (Ordovician) from Keisley, Westmoreland, there are suggestions of similar bodies, but they are not so definite as the others, which is a condition to be expected in rocks of that age and crushed as they are.

In view of these observations, and of the somewhat similar structure mentioned as occurring in some Permian limestones of west Texas, it seems that a thorough investigation of thin-sections of limestones of all ages, including those of Recent deposits such as are now forming in the Bahamas, might throw considerable light on the subject. There is evidence from observations so far that spherical bodies similar to those in the Georgetown limestone are present in rocks of widely different ages. If this be substantiated, and the structures shown to be the same, there can be little doubt that they are of inorganic origin. If they do originate around gas nuclei, there is no reason why they should not occur in many limestones of different ages. Before basing too much on the gas-bubble theory, it would be valuable to have further details about the structure mentioned by Dr. Vaughan, the size of the bodies, nature of their wall, and conditions governing their formation. These lines of attack may yield results, and they should not be neglected.[6]

[6] In connection with the study of some Cretaceous foraminifera in Texas strata by the Bureau of Economic Geology, Austin, Texas, opinions of a few competent geologists were solicited as to the nature of the minute globular bodies in the Georgetown limestone, which has popularly been known as the "Orbulina rock." Two reports were published in Bulletin 3101, Bureau of Economic Geology, but this paper reached Austin too late to be included. The conclusions offered by Mr. Thomas have been reached independently of those published in the bulletin. His broad treatment of this problem adds much of interest for those workers who deal with thin-sections of limestones widely distributed both geographically and stratigraphically.—HELEN JEANNE PLUMMER.

NEW NAMES FOR TWO SPECIES OF CRETACEOUS OSTRACODA

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Mr. P. V. Roundy, of the United States Geological Survey, has kindly called the writer's attention to the fact that two of the names employed in describing new species in the writer's paper "Ostracoda of the Cretaceous of North Texas," (Univ of Texas Bull. No. 2907, 1929) had been previously used by other authors.

For the species described as *Cytherella obesa*, p. 51, and preoccupied by Jones, Kirkby and Brady (*Monogr. Paleont. Soc.*, p. 75, 1884) I propose the new name *Cytherella bullata* n. sp.

For the species described as *Bairdia gracilis*, p. 60, and preoccupied by McCoy (*Synop. Carb. Foss. Ireland*, p. 165, 1844), I propose the new name *Bairdia roundyi* n. sp.

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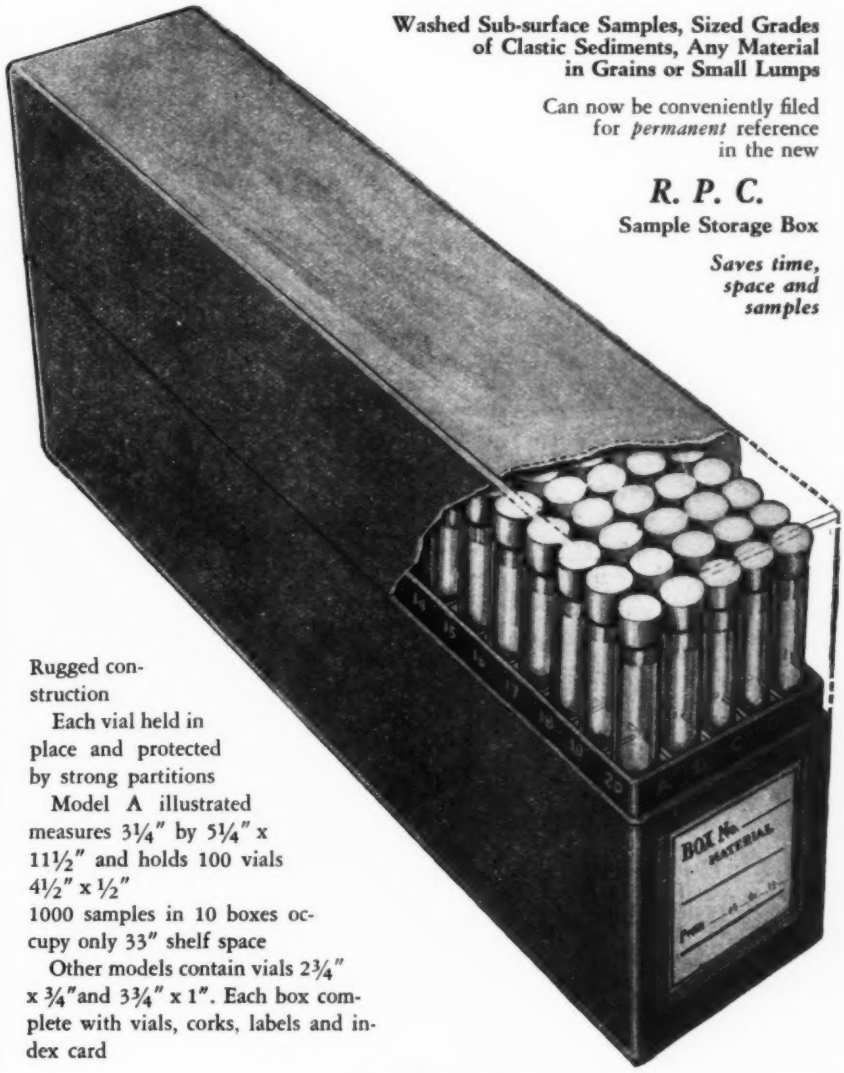

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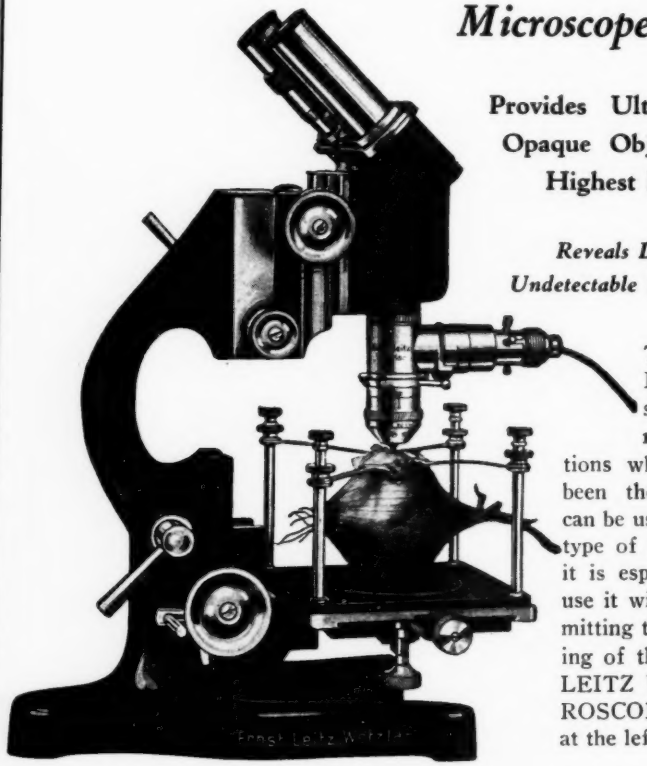

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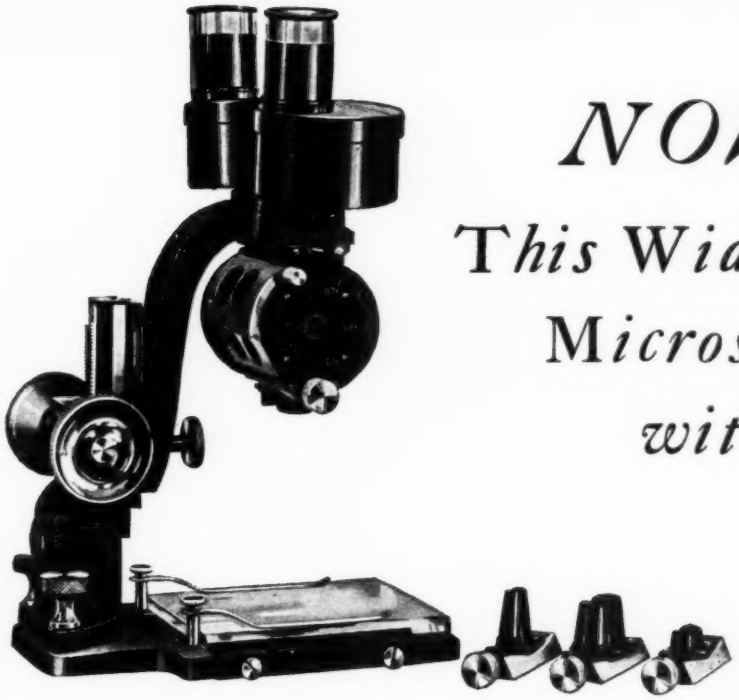

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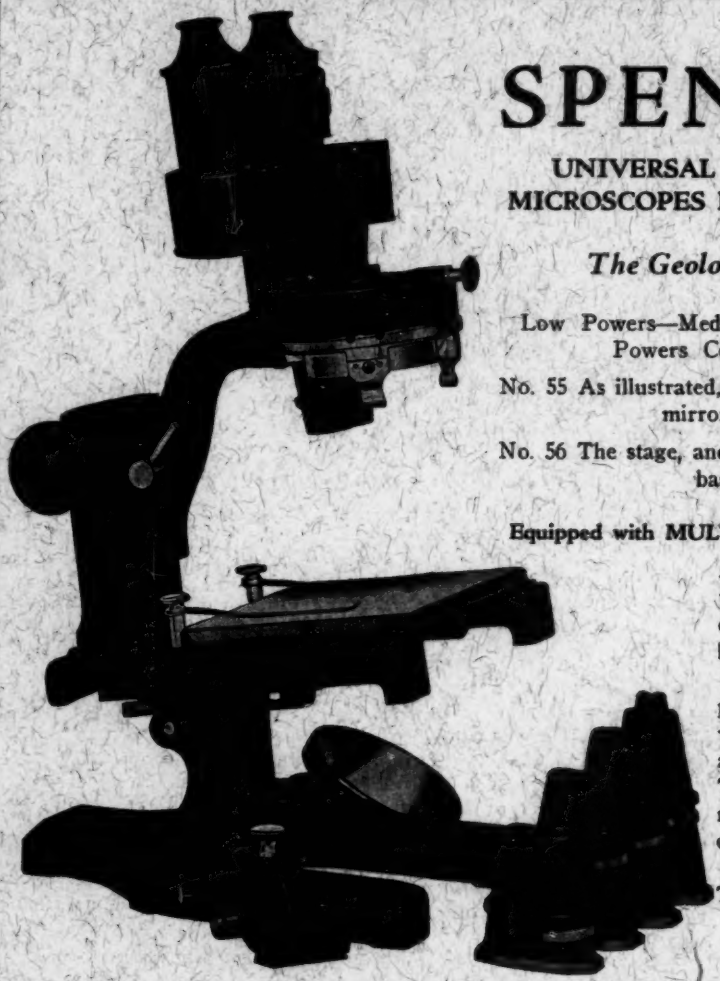

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The Geologists' Ideal

Low Powers—Medium Powers—High Powers Convertible:

No. 55 As illustrated, with horseshoe base, mirror, etc.

No. 56 The stage, and above that, omitting base.

Equipped with MULTIPLE NOSEPIECE

A new original objective changer which carries three pairs of binocular objectives (either high or low power) and which revolves like an ordinary triple nosepiece. The objectives may be removed instantly and others substituted.

The objectives on the nosepiece are dust proof.

These microscopes have a very large stage 100 mm. x 100 mm. Objects in the center of a dish 50 mm. high and 130 mm. in diameter may be brought into the lines of vision. The rack and pinion movement, together with the adjustability of the arm on the slide, permits the focusing on very thick objects. The large mirror (62 mm. diameter) is sufficient to illuminate the large fields of the low power objectives.

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